Proceedings
of the
Twenty-fifth Indian Science Congress

CALCUTTA, 1938

PART IV

LATE ABSTRACTS, ERRATA AND ADDENDA, DISCUSSIONS, LIST OF MEMBERS AND INDEX

Published by the Royal Asiatic Society of Bengal,
1, Park Street, Calcutta
1939

Proceedings of the Twenty-fourth Indian Science Congress

HYDERABAD SESSION, 1937

ERRATA AND ADDENDA

(1) *Section of Agriculture.*

The following abstracts of the Section of Agriculture which were deleted from the final Proceedings of the 24th (Hyderabad) Session are printed and supplied loose with Part IV of the Proceedings of the 25th Session for inclusion in the Proceedings of the 24th Session between pages 376 and 377.

Crops—Genetics

64. Inheritance of floating habit in rice (*O. Sativa*).

K. RAMIAH *and* K. RAMASWAMI, Coimbatore.

There are certain special varieties of rice known as floating rices which are grown under deep water conditions. They are generally characterized by very long and weak straws with a spreading habit forming roots at each of the nodes above ground level, keeping themselves afloat with the rise in the level of water and coming down, flat on the ground when the deep water conditions are absent. A cross between one of the floating types and an ordinary cultivated type with erect and stiff straw studied up to F_3 generations at the paddy breeding station Coimbatore, shows that two recessive factors control the floating habit, a ratio of 15 : 1 of normal to floating habit being obtained in the F_2 generation. There is also a definite linkage relationship between the floating habit and the length of the straw.

Crops—Diseases

65. On Urocystis Sorosporioides Koernicke.

B. B. MUNDKAR, New Delhi.

Plants belonging to the genus *Delphinium* were found to be attacked by a leaf smut at Simla in 1935. Small pustules which very often coalesce when lying side by side are formed on the leaf-blade. The pustules are erumpent and circular and both dorsal and ventral epidermal tissues of the blade are arched outwards. Ventral side cells are elongated and the place of the mesophyll is taken up by the nutritive mycelium which is later turned into spore-balls.

Sori are greyish and spores, black in mass; spore-balls are round to obtuse, compact, opaque. Measurements of spore-balls, fertile and sterile cells are given. The smut belongs to the genus *Urocystis* and of the three species affecting the members of the family Ranunculaceæ, this agrees in its morphology and spore-measurements with *U. Sorosporioides* Koernicke.

The genus Urocystis has been merged into the older genus *Tuburcinia* by Liro but reasons for not accepting this arrangement in the present state of our knowledge regarding spore germinations of these two genera are given. This is the first record of this fungus for India.

66. Blank shank of tobacco in the Madras Presidency.

B. B. MUNDKAR, New Delhi.

In diseased tissues of tobacco plants suspected of blank shank at Anakapalle an unseptate mycelium was observed which, on incubation, developed sporangia of a *Phytophthora*. Comparative studies with authentic cultures of *P. parasitics var nicotianæ*, the casual organism of black-shank indicated that the suspicion was correct. The disease had been previously recorded by the Government Mycologist, Coimbatore, in two other parts of the Madras Presidency.

In pot experiments the fungus was virulently pathogenic to transplanted tobacco, though in the seed beds *Pythium* spp., and *Rhizoctonia* spp., were more destructive. Well established plants infected without wounding showed early symptoms in eight to ten hours and succumbed on the second or third day recoveries being very few. Other *Phytophthora* spp., were unable to attack the plants and *Pythium aphanidermatum*, stated by Butler to be parasitic to transplanted tobacco in Nyasaland, was non-pathogenic under Pusa conditions.

The fungus is principally soil-borne. Fungicides, proved infective. In the cool months of November to March, the fungus was unable to cause disease, but in hot weather it became active again.

Of the eight Pusa varieties tested the 'hookah' tobaccos (N. rustica) were less susceptible. Two resistant tobaccos obtained from Florida maintained their resistance even at Pusa.

(2) *General Discussion*—V. Conditioned Reflexes.

Sections of Physiology and Psychology.

The discussions on conditioned reflexes, *vide* p. 493 of the Proceedings of the 24th (Hyderabad) Session, was presided over by MR. K. C. MUKERJI, M.A., *President of the Psychology Section* and not by LT.-COL. S. L. BHATIA, M.C., M.A., M.D., B.Ch., F.R.C.P., F.R.S.E., I.M.S., *President of the Physiology Section*, as stated thereon.

Proceedings of the Twenty-fifth Indian Science Congress

PART IV—LATE ABSTRACTS, ERRATA AND ADDENDA, DISCUSSIONS, LIST OF MEMBERS AND INDEX

CONTENTS

1. LATE ABSTRACTS

Section I, Mathematics and Physics.

44. The dielectric constants of solid bodies.[1]

C. G. Darwin, Cambridge.

The question of the electric and magnetic fields inside solid bodies is one which seemed to have been settled long ago, but Lorentz's term in $\frac{4\pi}{3}$ P introduces difficulty in the case where the dielectric constant is due to polar molecules, and not merely to the fields induced in atoms. The consequence ought to be that below a certain critical temperature the substance would acquire a permanent electric moment, like a permanent magnet. This effect does exist for a few peculiar substances, but is rare, whereas the old theory suggests that it should be common, and be particularly strong for water. Similar rules should apply for magnetism but the effect would only appear at temperatures of about 0.01°K. Such temperatures have recently been reached, and the substance does not become a permanent magnet at it, but appears to do so at a considerably lower temperature. Thus both for electricity and magnetism the theory needs modification.

The necessary change has been made independently by Onsager and Van Vleck. The idea they introduce is that each molecule is not under the average field, as in Lorentz's theory, but under this field modified by the fact that it is itself disturbing its neighbours. When this is allowed for, it appears that there is certainly no permanent electricity at the critical temperature, and no evidence that it must occur at all. The method is approximative, and is not capable of saying what will happen at these lower temperatures, but it does free us from what seemed a blank disagreement between theory and experiment.

99. The values of the atomic constants.

H. R. Robinson, London.

For some years there has been a puzzling discrepancy between the 'oil-drop' and 'X-ray' values of the electronic charge, the two being very nearly in the ratio 136 : 137. This discrepancy now appears to have been satisfactorily explained, and it seems likely that the X-ray value ($4{\cdot}802\times 10^{-10}$ e.s.u) is correct.

The adoption of this value of e leads, however, to difficulty in interpreting the measurements of certain related constants, and particularly the measurements of the ratio h/e. In spite of the attention recently concentrated on the accurate measurement of e, e/m_0 and h/e, and the apparently very considerable improvement in methods, it is evident that the exactness of our knowledge of these constants still leaves a great deal to be desired.

100. On units and dimensions.

Sir J. B. Henderson, London.

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[1] Published by title only in Part III, Abstracts, page 16.

101. Hard cosmic ray showers.

W. Bothe, Heidelberg, Germany.

In the usual shower produced by cosmic rays, the average angle subtended by the tracks of positrons and electrons at the point where the shower is originated is about 20°. The secondary particles forming the shower are completely absorbed by a lead sheet about 2 cm. thick and for this reason these showers may be called soft showers. The properties of the shower of a second kind observed by the present author have been described in the present paper. These showers are much harder than the usual showers and the angle of divergence is below 10°. It is pointed out that the second maximum in the Rossi curve is more pronounced at angles smaller than 10° than at larger angles, and that this can be attributed to the production of tertiary showers by the hard shower. The intensity of the second maximum in the Rossi curve produced by the hard shower is proportional to Z per atom while that in the first maximum due to soft showers is proportional to Z^2 per atom. As regards the origin of the hard showers, it has been observed that they are produced by the hard component of the primary cosmic rays.

Section V, Botany.

In connection with Abstract No. 22 of Section V, Botany, page 143 of Part III of the Proceedings of the 25th Indian Science Congress, dealing with 'The structure of the chromosome' Prof. R. Ruggles Gates has sent the following summary of what he actually said at the meeting.

22. The structure of the chromosome.

R. Ruggles Gates, London.

This paper discusses particularly (1) the time of splitting of the chromosome and the number of threads it contains, (2) the chromomere *vs.* the chromonema hypothesis, (3) the satellited chromosomes, their relation to the nucleolus and to chromosome phylogeny.

It is pointed out that various appearances have been interpreted as chromomeres when in reality uniform chromonemata were involved. Various errors of observation, technique and interpretation have led to a false appearance of granules on a thread. The hypothesis of chromomeres therefore requires further investigation, especially as regards the supposed relation of chromomeres to 'genes'. Much recent work has shown that the chromosome consists of spiral threads of relatively uniform thickness, the spirals becoming loosest in interphase and tightest in metaphase of mitosis.

The extensive recent work from many laboratories is reviewed, which shows that chromosomes are double structures consisting of two chromonemata variously intertwined in all stages of mitosis, the new split occurring at or about prometaphase. A very large amount of direct observational evidence thus nullifies the idea that chromosomes are single and that the meiotic prophase therefore differs from mitosis in the postponement of the split in the leptotene thread. The leptonema has in fact been clearly observed to be double in a number of cases. Chromosomes have also been shown to be composed of four strands in somatic metaphase and of two intertwined strands in anaphase and telophase. Recent work with Trillium, in which the chromosomes are so large that the details of their structure are far above the limits of resolution, shows that the anaphase chromosomes contain two intertwined chromonemata, while the metaphase chromosomes are composed of four chromonemata

intertwined in pairs. The X-ray experiments bearing on chromosome structure are critically reviewed. It is shown that the evidence is both indirect and conflicting. Each investigator has moreover interpreted his results as supporting the views he already held. This is true of those who hold that the chromosome is (*a*) single, (*b*) double, (*c*) quadruple. It is therefore concluded that the X-ray evidence is too indirect and uncertain to be of value in comparison with the direct observation of structure in the larger chromosomes.

The importance of the satellites in relation to the nucleoli is pointed out, and it is shown how several lines of evidence can be used in a complementary way in tracing the phylogeny of nuclear structure in primary or secondary polyploids: (1) the maximum number of nucleoli in early telophase nuclei, (2) the number of satellited chromosomes and the size of the satellites in somatic and meiotic mitoses, (3) the maximum secondary pairing of bivalents in first and second metaphase. Loss of a satellite in a polyploid has apparently occurred through mutation in various genera. Strains lacking a pair of satellites can arise in this way.

[Paper No. 27 on page 145. Abstract not supplied before is given herewith. The title of the paper is slightly amended.]

27. The sexual process in the Rust Fungi.

A. H. R. BULLER, Kew.

There are three ways now known in which the sexual process in the Rust Fungi may be initiated: (1) by the fusion of a (+) mycelium with a (−) mycelium, as first observed by Craigie in *Puccinia helianthi* and *P. graminis* and as subsequently confirmed by Brown by means of critical experiments made on *P. helianthi*; (2) by the fusion of a dicaryotic or diploid mycelium (derived from a uredospore) with a haploid mycelium (derived from a basidiospore), as observed by Brown in the autoecious rust, *Puccinia helianthi*; and (3) by the union of a pycnidiospore with a flexuous hypha of opposite sex, as observed by Craigie in *Puccinia helianthi* and recently by the writer in *P. graminis*.

The writer has observed between eighty and one hundred unions between pycnidiospores and flexuous hyphae in *Puccinia graminis*. A union takes place (1) at the end of a flexuous hypha or (2) at the end of a short lateral branch or peg emitted from the side of a flexuous hypha. Not a single fusion between a pycnidiospore and a periphysis (paraphysis) was seen.

The paper was illustrated with lantern slides and models.

Section IX, Agriculture.

57. The present state and future development of potato breeding.

REDCLIFFE N. SALAMAN, Cambridge.

Potato breeding in England and in Western Europe has reached a stage at which no further improvement is to be expected by the use as parents of any of the existing commercial stocks. This is due to the fact that whilst all objectionable qualities, and with them perhaps much that gave vigour and constitution, have been bred out of the original stocks, and desirable characters such as high cropping, colourless skin, smooth eyes, good shape, good quality, maturing habits and the like, combined with resistance to wart disease, have been retained, there is no further reserve of genic character to draw on. The qualities most to be desired, resistance to blight and virus disease, are missing from all

our stocks. These qualities can now only be obtained by the introduction of new blood from wild species or unrelated cultivated stocks such as may be found in Mexico and South America.

In 1908 the author showed that resistance to blight was controlled by genetic factors and that such resistance occurred in S. edinense and S. demissum. Crosses with S. demissum were begun in 1914 and have been carried on till the present time, using frequent back-crossing and testing each generation for resistance to blight, and economic qualities. The result is that potatoes have been bred which are resistant to the common form of blight, but new strains of *Phytophthora infestans* have appeared, to which they are not resistant. The introduction of still further wild blood has given us potatoes immune to both this and the common blight. There is no reason to hope that before long the task of producing a good economic blight-resisting potato will have been solved.

As regards resistance to virus, there is some hope that resistance to some of the diseases may be obtained from such wild species as S. Ribini. Even, if this resistance is genetic in character there still remains, the task of carrying it over to our economic varieties, which may be difficult without bringing with it the many undesirable qualities peculiar to S. Ribini.

The author is of opinion that valuable progress may be made by protective inoculation methods by which non-virulent virus strains are used as vaccines to protect susceptible plants against infection with virulent strains. This method has shown considerable promise in the laboratory. Inasmuch as such vaccines are naturally carried to the forthcoming tubers, the method allows of a really practical application.

58. Hundred ton sugarcane crop.

SETH LALCHAND HIRACHAND, Bombay.

The author showed a cinema film depicting the growing of a hundred ton (per acre) crop of sugarcanes in parts of Bombay. Such crops were raised in response to the announcement of a prize of Rs. 1,000 for a hundred ton (per acre) crop of sugarcane under certain conditions in the matter of maintenance of records, etc. Subsequently a second prize of Rs. 500 was offered for the highest yield of sugar per acre as well. The prize was given, at the instance of Mr. Wallchand Hirachand, by Messrs. Marsland Prize & Co., Ltd., Bombay. Such a heavy crop was rendered possible mainly through four factors, viz., (1) thorough cultivation, (2) heavy manuring, (3) heavy irrigation, and (4) close and careful supervision. Such a crop was obtained from what is known as 'Adsali' crop in the Deccan which stands in the field for eighteen months or a little over.

All needed precautions were taken in the harvesting of the prize plots and estimating available sugar, technical men being told off for the work. Harvests of over 100 tons of canes were recorded from three of the prize plots, the variety being P.O.J. 2878. These results are very striking in view of the general belief at the time of the announcement of the prize that it was almost impossible to raise a hundred ton crop in the areas where the competition took place. The estimated available sugar was, in three cases, over 11 tons (being a little over 11½ tons in two of the plots).

59. The rôle of sugarcane crop in the domestic economy of the Punjab cultivator with special reference to the years of economic depression.

KHAN BAHADUR FATEH-UD-DIN, Simla.

Cost of cultivation of sugarcane in the Punjab has been worked out. It is the highest among the provinces. The yields per acre here are far below the rest of India and yet the Punjab has the second largest area

among the provinces. These points led the authors to make a comprehensive study of the statistics of the crop and this has revealed some very interesting facts. A detailed study has been made of the fluctuations in acreage under this crop during the last three decades. The quinquennial averages have been worked out, which for the quinquenniums ending with 1925-26, 1930-31 and 1935-36 have been 427, 737, 415, 983 and 487,088 acres respectively. The quinquennium ending with 1935-36 represents the years of general agricultural depression. A marked increase in area during this period has been of special significance, the reasons for which have been discussed at length. The index numbers of prices have been calculated for wheat, cotton and oilseeds and have been distinctly higher for the latter commodity during the years of agricultural depression. Hence the tendency to put larger area under this crop. The year 1932-33 recorded the maximum acreage since the beginning of this century. The prices during that year were also the lowest that ever prevailed since 1913-14. The effect of acreage on price of gur has also been studied.

About 1.5% of the total area of crops falls under sugarcane, but the crop is far more important than these figures indicate. The gross value of the return per acre is much higher than other money crops. The spare labour with the cultivator—manual as well as bullock—is economically utilized. Taking all these facts into consideration the importance of this crop in the province has been brought out.

The percentage that value of this crop bears to the total value of money crops in the province has been worked out for the different quinquenniums. This percentage during the years of agricultural depression has been distinctly higher than the same for the pre-depression years.

Evidently the crop has played a very important rôle during the days of general depression.

2. ERRATA AND ADDENDA

Proceedings of the Twenty-fifth Indian Science Congress

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PART III—ABSTRACTS

(1) *Section of Medical Research.*

[Paper No. 86 on page 256 of Part III of the Proceedings of the Silver Jubilee Session.]

The first paragraph of the abstract should read as follows:—

'It-ching (635–713 A.D.) during his ten-year stay at Nalanda made a successful study of the science of medicine. Translated a medical work 'Bhaishajya Vasthu'. His most famous book is the 'Record of Budhistic Religion as practised in India', in which he devotes many chapters to the rules of hygiene and the principles and practice of medicine in order to satisfy the needs of the time.'

(2) *Section of Geology.*

[Paper No. 18 on page 113 of Part III of the Proceedings of the Silver Jubilee Session.]

The names of authors of the paper should read:—

18. Tertiary basalts of Bombay Island.

V. S. DUBEY, Benares *and* H. S. DALAL, Bombay.

(4) *Section of Mathematics and Physics.*

[Paper Nos. 8 and 9 on page 3 of Part III of the Proceedings of the Twenty-fifth Indian Science Congress.]

The names of the authors in the above abstracts should be interchanged as follows:—

8. Diamagnetic susceptibilities and molecular structures.

K. BANERJEE *and* J. BHATTACHARYA, Dacca.

9. Electron map of anthraquinone crystal by Faurier summation method.

K. BANERJEE *and* S. N. SEN GUPTA, Dacca.

3. DISCUSSIONS

I. THEORETICAL STATISTICS.

(Section of Mathematics and Physics, in co-operation with the Indian Statistical Conference.)

[No report of the discussions has been received.]

II. RECENT ADVANCES IN THE STRUCTURE OF ALKALOIDS.

(Section of Chemistry, in co-operation with the Indian Chemical Society.)

1. Dr. J. N. Ray, Lahore.

   Recent methods used in the determination of the alkaloids.

2. Prof. K. Ganapathi, Bangalore.

   The structure of the strychnos alkaloids and the biogenesis of the alkaloids.

3. Dr. R. H. Siddiqi, Aligarh.

   The molecular structure of strychnine and brucine.

4. Dr. S. Siddiqui, Delhi.

[No report of the discussions has been received.]

III. CHEMISTRY AND INDUSTRIAL DEVELOPMENT IN INDIA.

(Section of Chemistry, in co-operation with the Indian Chemical Society, and the Society of Biological Chemists, India.)

1. Dr. T. S. Wheeler, Bombay.

Chemistry plays a preponderating part in the application of science to the development of natural resources. In order that it may fill its role in this country it is essential that there should be a regular supply of well-trained industrial chemists. It is necessary therefore that the Universities should provide courses in technical chemistry based on an adequate foundation of pure chemistry, and giving if possible opportunities for specialization in one or two major industries. The development of Departments of Applied Chemistry is expensive and it is essential that Universities should combine to prevent overlapping; all should have the equipment for general training and provision for specialized training in one major industry not covered elsewhere.

The Universities can also help by basing their research programmes on the problems of local industries and their technical chemical staffs should be encouraged to keep in direct touch with these industries. Besides promoting the development of local resources such co-operation will facilitate the provision of posts for University students.

Close co-operation is also advisable between the Technical Departments of Universities and the local Departments of Industries; the latter can supply much valuable information regarding the industrial needs of the Province and the manner in which applied Science can help in solving local problems.

2. Drs. R. B. Forster *and* K. Venkataraman, Bombay.

Chemistry and Industry.

Chemistry has played the dominant part in the development of the textile industry in recent years. The complete elucidation of the structure of cellulose and of the constituents of silk and wool has given the processer a knowledge of the nature of his raw materials, which has enabled him to achieve a closer approach to his ideal of producing a desired result in feel and appearance without prejudice to fibre strength. Regenerated cellulose and a variety of other synthetic fibres, individually and in admixture with the natural fibres, have opened up a new range of attractive fabrics. Following Bohn's discovery of indanthrene blue in 1901, the dyer has now at his disposal dyes of a degree of fastness not only hitherto unsurpassed, but representing a permanence greater than that of the fibres themselves. All the colours of the spectrum are available, including the greens; and simplification of the methods of application in dyeing and printing has also become possible. Chief among the advances in dyestuff synthesis are the indanthrenes, the Naphthol AS series discovered by the Griesheim Elektron, the stabilized diazo salts, the solubilized vat colors, the Neolans (water soluble mordant azo dyes containing co-ordinated metal), colloidalized dyes for acetate silk and the Rapid Fasts and Rapidogens for printing. The fastness to washing of dyeings with substantive colours is improved by after-treatment with certain quaternary ammonium salts and allied substances (Fixanol, Sapamine, Solidogen). Scouring, dyeing and other processes have been facilitated by numerous 'auxiliaries', polar substances of more or less complex character, belonging to the aliphatic, aromatic, hydroaromatic and heterocyclic series and possessing one or more of the properties of wetting, emulsification, detergency, dispersion of calcium soaps, promotion of level dyeing, softening of textiles and the ability to impart a special feel or handle to fabrics. The chemical aspects of finishing have become more important than the physical processes of mangling, stentering and calendering. Some examples of such chemical finishing of cotton fabrics are the partial or surface solution of cellulose (superficial rayonization), proofing against damage and deterioration of various kinds (water, mildew, moths, heat, fire), immunization and animalization, and 'anticreasing' by the incorporation of synthetic resins. Lastly, chemistry has not left untouched even the machinery side of the industry; stainless steel and composition materials are being increasingly employed in the construction of dyeing equipment.

The Indian textile industry has so far been content to derive at second hand the benefits of this many-sided progress, and has done little or nothing to make similar advances on its own account. The institution by the University of Bombay of a department of textile chemistry is a first step to bring the largest Indian industry into live contact with chemistry and chemists. The need for rigorous scientific control of processes and for the local production of the chemicals and auxiliaries consumed by the cotton industry is receiving recognition.

Dr. R. B. Forster, Bombay, said:—

Although the dyestuff industry is probably the most complicated industry in existence, it requires very few starting products and the plant involved is comparatively simple.

By the distillation of coal tar over 200 products have been isolated. Out of these only a few are of importance in dyestuff manufacture, namely, Benzene, Toluene, Naphthalene and Anthracene and to a lesser extent Phenol, the Cresoles Xylene, Carbazol. The establishment of a tar distillation plant would therefore lay the foundation stone of the manufacture of dyestuffs and in addition would lead to the establishment of a number of other industries such as the preparation of disinfectants, wood preservatives, motor fuels, fine chemicals, pharmaceuticals, photographs, synthetic resins, solvents, synthetic tannins and the like. The tar distillation industry is, however, not essential as sufficient benzene can be obtained by stripping coal gas and naphthalene is easily imported and with these two raw products a very large number of dyes may be manufactured.

The heavy chemicals, namely, concentrated sulphuric acid, nitric acid and hydrochloric acid are already made in India and several factories for the manufacture of sodium hydroxide and sodium carbonate are in the course of erection. If any of these operate on the electrolytic system, a cheap supply of chlorine should also be available. Provision would have to be made for the production of oleum as many of the sulphonations can only be carried out by its use. The preparation of chlorsulphonic acid from oleum is a simple matter, involving only a supply of oleum and hydrochloric acid. The remaining essential chemicals, such as calcium carbonate, lime, iron, acetic acid, acetic anhydride, ethyl and methyl alcohols should present no difficulty.

The principal reactions in dyestuff manufacture are sulphonation, alkyl fusion, nitration, reduction and chlorination for these operations only simple plant is required consisting of sulphonation and nitration pots, autoclaves and reduction vessels together with aucilliary plant such as filter presses, pumps, nontjus and wooden vats. In connection with the latter, India possesses a great advantage over other countries in as much as she possesses an unlimited supply of teak wood, one of the finest woods for the manufacture of chemical plant.

In the initial stages it would be advisable to import the plant required, but as the industry developed it should be possible to fabricate in India a number of the items which require cast iron, mild steel or copper for their construction. Incidentally this would produce another outlet for the iron foundries and engineering firms.

Apart from its influence on other industries, the dyestuff industry is of enormous importance from a national point of view. What would happen for example if the supply of dyes was cut off or restricted. There is an enormous amount of capital invested in the mill industry and not only would the share holders go dividendless but numbers of work people would be thrown out of employment.

An industry of the nature could not be built up in a day and in the initial stages many of the external products would probably have to be obtained from outside sources. In the case of a dye like Congo Red it is possible to start with Benzidine and Naphthionic acid gradually work backwards—when in due course the starting points would be Benzene and Naphthalene. After all half a loaf is better than no bread.

3. Dr. B. C. Guha, Calcutta.

Development of chemical industry in India.

During recent years throughout the world there has been increasing co-operation between pure science and applied science. Not that the distinction was ever water-tight, but of late the conscious application of science to human and social benefit has been greatly stimulated. This

need is all the greater in this country, where industry is still in its infancy. So far as chemistry is concerned, the situation is not very much better, many of the basic chemical industries being absent while most of the others largely concerned with drugs have to depend on imported chemicals. Coal is an example, where nothing is derived except coke, tar and coal gas, all other valuable bye-products being wasted.

For the starting of many chemical industries, talents inside in the country are available. Raw materials and sources of power are also available. Experience shows that many machineries can be made according to design inside the country. But it has been felt that the requisite contact between scientists on the one hand and industrialists on the other has been lacking. I beg to suggest that organizations may be set up, which would represent (1) University Science departments, (2) the Industries Departments of the Central and Provincial Governments, and (3) the Chambers of Commerce. Establishment of such contacts would, I think, help to infuse a greater sense of reality into the work of the University Science Departments and make them more responsive to industrial needs. Industrialists would at the same time realize what help science is capable of rendering to industry. This may reasonably be expected to lead to the establishment of new industries and expansion of the old.

So far as Applied Chemistry teaching in the University is concerned, it is suggested that there should be greater co-ordination among the different Universities. While each centre should give instructions in the fundamentals of chemical technology, it is desirable that a centre should specialize only in particular directions, depending on its peculiar environments and local industrial possibilities.

4. Dr. H. K. Sen, Ranchi.

Lac research in India.

Dr. H. K. Sen, Director, Indian Lac Research Institute touched upon three points :—

The training in the Universities is not being fully useful as the students do not have a truly machine sense. The latter can be developed by beginning such training in its elements from the age of 4 or 5 in the schools. Carpentry, gardening, visits to museums, etc. Machine drawing is the language of the technical man, and the imagination of the student must be properly developed to get an efficient technical staff. The Universities of the country should, therefore, examine this question and create such changes in the elementary school curricula that would help to develop this machine sense.

He then mentioned the need for investigating the fuel and the fibre problems. We have a small coal deposits and any method of economy in this industry would be of vital national economy. He specially referred to low temperature carbonization of Indian coals which he thought would introduce real economy in the fuel industry on the one hand, and would simultaneously yield the tar as a proper raw material for various chemical industries. Incidentally he mentioned a simple plant which he and his colleagues had developed during the last six years in the University of Calcutta, which could provide all Universities and technical establishments with gas at practically no cost, and furnishing the tar for examination by a body of research workers whose wages would be found from the economy in the cost of gas production itself.

The fibre industry which is of equally great importance deserves similar attention. The cane sugar industry has brought within reach a fibre the value of which remains as yet unutilized. For building materials such and other fibres should be intensively investigated.

In the end, Dr. Sen deplored the want of proper co-operation between the technical man and the capitalist, which, to his mind, is the real

reason for the absence of big industries. Initiative and enterprise, and more than all, the combination of the capitalist and the technical man would create a different phase in the future of Indian industry.

5. Drs. H. B. Dunnicliff, Gilbert J. Fowler, V. Subramanyan, K. Venkataraman, K. G. Naik, M. S. Patel, K. L. Mudgill *and* Miss Ram, took part in the discussion.

6. Sir Henry Tizard.

Sir Henry Tizard suggested the appointment of research boards by the Indian Science Congress.

IV. PRE-CAMBRIAN SEDIMENTATION.

(Section of Geology.)

1. Mr. B. Rama Rao, Bangalore.

Including under the comprehensive term Pre-Cambrian all the rock formations anterior to the great eparchean interval, the main features of sedimentation of the Archean times as exemplified in the Dharwar rocks of Southern India are dealt with. The process of sedimentation of this extensive era has been considered under three periods.

During the first or the oldest period, there was a dominance of vulcanism with hardly any sedimentation. Such of the few types as could be recognized as possible sediments are of the nature of chemical depositions, mainly siliceous, derived from the decomposition of their closely associated volcanic rocks which in parts at least, seem to have been sub-aqueous. Towards the top of the period, signs of disintegration probably under hot moist conditions, and mechanical sedimentation become apparent, but still the processes of weathering were incomplete and the weathered products were never conveyed far from their sources.

During the second period, specially towards its end, signs of setting up of meteoric conditions akin to those of the present day are better evidenced. Graphitic carbon and graphite are conspicuous in some of the rock types, indicating the probable advent of the original primitive plant life at about this period. There was still considerable amount of chemical deposition,—and this time lime, iron and silica were the products of precipitation. There was also mechanical deposition. The possible sources of material for these sedimentations with reference to environment, the nature of the depositional basins and the conditions of deposition, etc. are briefly touched upon.

The end of the era indicates conditions of sedimentation not very different to what are commonly observable at the present day. The sedimentary material of this period represents the broken down products of the various types of pre-existing rocks ; transported, sorted and deposited like the present day sediments.

2. Dr. M. S. Krishnan, Calcutta.

Most of the sedimentary types in the Pre-Cambrians do not call for special comment. The iron formations and manganiferous rocks are peculiar in that their deposition has not been repeated in later ages to a similar extent or magnitude.

The banded iron-bearing rocks are widely distributed in India—in Orissa, Central Provinces, Bombay, Hyderabad and Mysore. Most of them at any rate are of sedimentary origin, the iron being probably derived from the weathering of pre-existing rocks. Some of the deposits have

been metamorphosed, giving rise to magnetite-schists and magnetite-amphibole-schists. Superficial enrichment has given rise to important deposits of iron-ore of high quality. Other peculiarities of the formations are also discussed.

There are three different groups of manganiferous rocks in India, gondites, kodurites and manganiferous shales. From the original sediments gondites have been formed by metamorphism, while kodurites are products of hybridism between the sediments and igneous rocks. All the three types have given rise to residual ores, but the primary ores associated with the gondites are the most important.

Though iron and manganese occur in close association in rocks and minerals, on going into solution they tend to be segregated during deposition. The abundance of oxygen determines whether carbonates or oxides are to be deposited.

3. PROF. L. RAMA RAO, Bangalore.

In discussing any aspect of Pre-Cambrian geology, the following facts have to be remembered: (i) the Pre-Cambrian strata are of very wide extent, visibly covering nearly one-fifth of the whole land surface forming the shield areas; and even among the other four-fifths of the continents, they probably exist over large areas deeply buried under the later formations; (ii) their total thickness exceeds that of all the rest of the strata put together, and they thus represent a very long period of time—much longer in duration than the whole of the time represented by the Cambrian to the present day; (iii) the Pre-Cambrian beds of any area are not merely a series of deposits laid down one after another throughout the period; on the other hand, the sequence is frequently interrupted by prolonged periods of diastrophism and denudation, giving rise to unconformities which constitute 'the most wide-spread, strongly accentuated and deeply significant structural features' of this part of the geological record, and represent extensive featureless surfaces of peneplanation the like of which it is impossible to see during the later periods; (iv) due to the continual operation of two factors, magmatic absorption from below and denudation from above, it follows that what we now see of the Pre-Cambrian rocks form only a part—probably a very small part—of the entire original formation.

In the study of Pre-Cambrian sedimentation, two questions naturally come up for consideration: (*a*) what was the appearance of the face of the earth at the beginning of geological history?—was there a world sea encompassing the whole earth or were there, as now, continental blocks and sundering oceans? (*b*) was the composition and character of the primeval oceans and of the atmosphere under which they lay, the same as it is now? and were the processes of sedimentation—mechanical, chemical, and organic—similar to those of the present day?

In connection with Pre-Cambrian sedimentation, there is another important problem to discuss, viz., what part, if any, did life play in the building up of these ancient rocks. It is true that, of undoubted organic remains, there are very few indeed; and even these are mostly found only in the later Pre-Cambrian sediments. But yet, taking into account all considerations, there seems to be no doubt that many more forms of life flourished in the Pre-Cambrian seas than the actual fossil record indicates. Absence of fossils need not necessarily mean absence of life, particularly so in the case of so remote a period as the Pre-Cambrian. The Pre-Cambrian seas must have been teeming with life of a kind which could never be preserved in the fossil condition, but nevertheless played an important part in determining the course of contemporary sedimentation.

4. PROF. P. G. H. BOSWELL, F.R.S., London.

In connexion with the discussion on Pre-Cambrian sedimentation, Professor Boswell commented on the fact that in calcareous sediments

of much later date, e.g. Chalk and the Recent limy muds of the Bahamas, no trace often remained of the organisms which had played a great part in the formation of the deposits. It was possible, therefore, that organisms such as bacteria and algæ might have played an important part, even if an indirect one, in the chemical processes of Pre-Cambrian limestone formation. And the same might be urged, for some occurrences at least, of the banded iron ores.

The problem of Pre-Cambrian graphites associated with limestones was also of much interest. Now that so many rare elements were found by spectroscopic tests to be characteristically present in coal-ash (e.g. germanium, vanadium, etc.) and our knowledge of their occurrence in animals was increasing, a spectrographic study of graphite associated respectively with limestones and igneous rocks seemed to be called for. Light might be thrown on the mode of origin of limestone graphite—whether organic or inorganic, and if organic, whether plant or animal—by such 'blood tests'.

5. Dr. C. Mahadevan *and* Mr. Syed Kazim, Hyderabad (Deccan).

Pre-Cambrian sedimentation in the Bhima-Kistna basin.

A series of sedimentary rocks consisting of conglomerates, sandstones, shales and limestones occupy roughly an area of about 2,000 square miles in the Bhima-Kistna basin. Their maximum thickness is computed to be less than 800′. Bruce Foote and King, two of the great pioneers of Indian Geology who surveyed this part of India about 70 years ago, gave them the name of 'Bhima Series' and relegated these formations, on lithological grounds, to the Kurnul Series of the Purana Group of Sir Thomas Holland. In the entire absence of fossils and stratigraphic evidence to assign their horizon with certainty, lithological considerations are the main criteria to fix their age. (Mem. G.S.I., Vol. XII, pp. 139 to 164).

During the recent survey of the Gulberga district by the Hyderabad Geological Survey, some observations of interest were recorded which are briefly reviewed here.

Bruce Foote divided the Bhima Series into two stages, a lower stage consisting of conglomerates, sandstones and shales, and an upper stage, of limestones, sandstones (local) and shales. The recent detailed study, however, brings out the fact that three distinct stages are recognizable in these sedimentary formations.

In the first or lowermost stage conglomerates and sandstones are succeeded by dull green, purple and red shales. Their total thickness is not over 200′.

In the next or middle stage limestones of cream, blue, black and buff colours were deposited. These have a maximum thickness of about 250′. Field evidence clearly suggests that during this stage the Bhima sea must have attained its maximum extent when dry land adjacent to the original sea underwent submergence. We therefore find that limestones sometimes directly overlie the Peninsular gneisses without the intervening sandstones and shales.

The third or upper stage heralds a period of upheaval. A great part of the area covered by the Bhima sea again became a dry land, mechanical sedimentation taking the place of chemical precipitation, in the area still covered by water. In this last stage, local beds of the sandstones along what seems a shore line, were formed. These are succeeded by buff, black, blue and purple shales. Naturally, oscillation in levels must have taken place during the period of deposition of these beds. The uppermost beds are confined to the northern and western parts of the Bhima basin.

The structural features presented by these formations are comparatively simple. The beds are nearly horizontal and except for

compaction show little evidence of metamorphism. Some faults have been noted, the longest of which is about 50 miles with a run of 30 miles West to East and about 20 miles South to North. This was traced eastwards from Honhalli (Lat. 26° 44′ 55″, Long. 76° 26′ 10″) through Gogi to Makhtapur (Lat. 16° 45′ 30″, Long. 76° 49′ 50″). From here it takes a northerly swerve to Radewadgi (Lat. 17° 40′ Long. 76° 47′ 50″). This is a normal fault with the throw varying from place to place.

A case of reverse faulting noted between Warchanhalli (Lat. 16° 51′ 12″, Long. 76° 48′ 30″) and Jewargi (Lat. 17° 18′, Long. 76° 46′ 20″) brought to light clearly by the data afforded by deep wells recently excavated in the area and by surface observations clearly proves that the Mudbal and Jewargi limestones are not intercalated beds in the Upper Shale stage as suggested by King (Mem. G.S.I., Vol. XII, p. 160). The anomalous position of the shales is seen to be due to faulting. It is surmised that the faulting took place subsequent to the deposition of the sediments. They are definitely pre-trappean in age. The beds dip at moderately high angles all along the fault line.

A feature of peculiar interest in these formations are the local occurrence of large scale slipping-in of beds due to the removal of the underlying layers. At Ladlapur (Lat. 16° 58′ 40″, Long. 77° 2′) a large mass of brecciated limestones is seen lying at the foot of a conical hill composed of shales, obviously displaced from the summit of the hill.

Recently, in the last session of this Congress, a suggestion was put forward that the salinity met with in southern parts of Gulberga district and in the Raichur district is mainly ascribable to concealed saline beds lying below the shales of the Bhima Series. That is to say, there were periods of marine regression and desiccation of parts of the basin, giving rise to saline beds which are supposed to have been overlaid by later sediments of the Bhima Series. This suggestion, i.e. of the alleged presence of concealed saline beds has been very carefully gone into by the Hyderabad Geological Survey during the recent work in the Bhima Series. Thanks to the systematic and extensive excavations of wells in this area by H.E.H. The Nizam's Well Sinking Department for village water supply, we have reliable and complete data on the quality of water available in these sedimentary formations through practically the full extent of the Bhima Series, and along the junctions of gneisses and sandstones, of sandstones and shales, shales and limestones, etc. hundreds of wells have been examined but no case of salinity was met with. A few isolated occurrences of brackish water, such as near Wadi railway station, are obviously due to contamination of surface waters through mantle of thick black cotton, soil, during filtration. We have also incontrovertible evidence that black cotton soil wherever it occurs, for example on gneisses, on Dharwars and Deccan Traps gives rise to sometimes salinity of the subsoil water.

No fossils have been so far met with, though conditions were most favourable for their preservation. Recent writers on sedimentation are inclined to ascribe the black and blue colour of the shales to organic origin. To what extent the black and blue shales of this area owe their colour to this agency will be an open question till some definite evidence of life is proved in these formations.

V. THE ORIGIN OF BANDED GNEISSES.

(Section of Geology.)

1. Dr. M. S. Krishnan, Calcutta.

Three types of banded gneisses have been observed in the Gangpur-Ranchi area of Chota Nagpur, viz., biotite-gneiss, calc-gneiss and amphi-

bolite-gneiss. The lighter bands in all these consist of aplitic or granitic material injected into the rocks in *lit-par-lit* fashion. The darker bands in the biotite-gneiss contain the usual constituents of biotitic schists; in the calc-gneiss the constituents are the calc-silicates actinolite, tremolite, epidote and zoisite; in the amphibolite-gneiss they are hornblende, quartz, clino-zoisite, ilmenite and sphene. The biotite-gneiss is found over a large area near the margin of the granite batholith of Ranchi, the granitization and banding dying away with distance.

The experimental work of Goranson in the Geophysical Laboratory at Washington shows that pegmatite and aplite crystallize within the temperature range of 700°–550°C. and quartz veins at still lower temperatures. A typical granite which contains 1% water, at a depth of 10 km., will give at a temperature of 700°C. a residual liquid which is 15% of the original rock with 6·5% of water in solution. The amount of water held in solution will depend on the pressure to which it is subjected. Hence, granite magmas at a depth of a few kilometres can be expected to give sufficient residual fluids to soak or to penetrate porous and schistose rocks in their neighbourhood and give rise to granitization and banding.

2. Mr. B. Rama Rao, Bangalore.

Banded gneisses have originated under different conditions and several types of such gneisses are recognizable in Mysore. All the various types may be broadly classed under the following three main divisions :—

(1) Banded ortho-gneisses ;
(2) Banded para-gneisses ;
(3) Banded composite gneisses.

In group (1), banding is generally noticeable due to the following conditions :—

(*a*) Flow banding produced at the margins of the later granites.
(*b*) Parallel orientation of coloured minerals in deformed granitic rocks.
(*c*) Incorporations of streaks and stringers of dark hornblende-schists in the granitic rocks producing various types of banding commonly noticeable in the Peninsular gneiss.
(*d*) Acid injections along planes of weakness in the hornblende-schists which have given rise to banded dioritic gneisses, banded hornblende-pyroxene-gneiss and several other types.
(*e*) Intermingling of granitic rocks and norites which have given rise to some banded hypersthene-gneisses.

(2) Crystallization of different layers of original sediments have given rise to certain types of banded gneisses and schists, like the sillimanite-cordierite-gneiss of Channapatna, and the various exposures of kyanite-sillimanite-gneisses of the south-west parts of Mysore.

(3) Certain garnetiferous micaceous gneisses, hornblendic micaceous gneisses, and cordierite-hypersthene-gneisses could be classed under composite banded gneisses, and in many of the outcrops of such rocks banding is seen to be due to lit-par-lit injections of acidic veins, in the original sediments.

3. Mr. L. S. Krishna Murthy, Dr. C. Mahadevan, *and* Mr. Syed Kazim, Hyderabad-Deccan.

Field observations in Raichur and Gulberga districts throw light on the origin of banding in the granitoid gneisses of the Peninsular complex. Some of the salient points of this study will be briefly stated.

Banding in the Peninsular gneisses may conveniently be classed under two main types :—

(1) Banding in the grey series produced by aplitic and pegmatitic phases of the same series and from injections of the pink series.
(2) Banding in both grey and pink series, produced by long runs of basic rocks. These are seen in the contact zone of the schists and gneisses.

4. MR. H. N. GANGULI, Calcutta *and* MR. G. C. CHATTERJI, Dhanbad.

The Origin of Banded Gneisses of Hazaribagh.

The rocks involved in the production of the hybrid gneiss in these areas are an older schist or amphibolite and a newer granitic (the present granite-gneiss—'dome gneiss') intrusive with its later pegmatitic phase.

The hybrid gneisses range from banded gneisses with distinct alternating bands of basic and acidic materials through streaky gneisses to homogeneous melanocratic biotite-gneiss.

There are evidences to prove that the pre-existing basic rock was invaded by an acid magma firstly inbroad patches, and thereafter more and more closely in a lit-par-lit manner. In places where penetration was complete homogeneous gneisses resulted.

The basic rock before incorporation in the granitic material was reduced to a plastic state which facilitated the intimate permeation of it by the invading magma. The plasticity is inferred from local fault of basic bands in the banded gneisses and from the ptygmatically folded acid veins in the basic rocks.

The first acid magma to invade the basic rocks was the main acid intrusive of the area. Later pegmatitic and aplitic material invaded the earlier rocks, probably still in the process of consolidation. The idea is corroborated by the occurrences of interstitial microchine in the gneiss and by the occurrence of pegmatitic and aplitic veins and dykes that cut across the bands of the banded gneiss, often sending veinlets along the banding planes of the gneiss. These pegmatites thus to a great extent had been responsible for the banding.

The microscopic evidence of the permeation of a basic rock by an acid one is furnished by (*a*) the intrusive relation of quartz with plagioclase and femic mineral and the formation of diablastic intergrowth; and (*b*) inclusion by the acid magma and its materials of the constituents of the basic rock.

During the earlier stages, i.e. during the period of mechanical shattering, augite was produced from hornblende, in the separated amphibolite bands, and a little quartz was introduced.

With more intimate penetration in the streaky gneiss more augite was produced from hornblende but in the more homogeneous varieties, i.e. where the penetration of the acid magma was completed, biotite is far more prominent than hornblende and augite, with usually a subordinate amount of muscovite.

With the thinning of acid and basic layers further interchange of materials between the invading and the invaded rocks took place, the evidence of which is furnished by the formation of myrmekite, etc. the basic rock was acidified and *vice versa*. Ultimately a uniform rock intermediate in composition between the amphibolites and the granitic rocks was produced.

Myrmekite is generally absent in the homogeneous gneisses due evidently to a more complete reaction between the invading magma and the invaded rock.

Sphene was formed around ilmenite due probably to reaction between the latter and some lime, that might have been available due to the interchange of material between the acid and the basic components of the hybrid gneiss.

5. Prof. H. H. Read, University of Liverpool, England.

In such an individualistic science as Geology, a discussion tends to become a symposium of a number of detached views. Each contributor gives an account of his own personal experiences, and it must be left to a master-mind to correlate and assess the various contributions. Particularly this must be so in a discussion dealing with so complex a subject as the origin of the banded gneisses. The best that we can hope for today, therefore, is to hear the personal views of those geologists present who have had occasion to deal with banded gneisses in the field.

Perhaps I can best begin my own contribution by stating a fact which, though obvious, is often ignored, and that fact is this:—a banded gneiss is a gneiss with bands, i.e. a gneiss with distinct more or less continuous layers of different compositions. I am not concerned with the homogeneous and massive varieties of metamorphic rocks.

The first enquiry that I wish to make is the following. Can dislocation-metamorphism produce banding? The only case known to me of the production of banding by pure dislocation is that of the ribbon-mylonites associated with clean-cut thrusts. Sheared rocks in general are not banded; on the contrary, shearing tends to obliterate banding present in the rock before it was subjected to shearing.

My second point concerns flow-banding in igneous rocks. This banding, apart from some developments in the gabbroic rocks, is restricted in extent,—original 'pure' igneous rocks are not banded. I believe that only a very minor proportion of the banded gneisses owe this character to a flow-banding in an igneous rock.

In my view, *banding in gneisses is inherited from or controlled by originally banded rocks.* Banding is therefore predominantly dependent upon original sedimentary structures. Banding in gneisses arises in two main ways:—

(1) by inheritance from pure sediments
(2) by an injection-process controlled by sedimentary banding.

I now consider these two cases.

(1) Banding may arise by the recrystallization of an originally banded sediment. In this process of recrystallization there is a chance that there may be a partial or complete destruction of the original sedimentary banding by the operation of metamorphic diffusion and metamorphic differentiation. In these two closely related processes, movement of material from one part of the rock to another takes place during the act of metamorphism. It is unwise, in my opinion, to believe that the different layers in a banded gneiss have compositions identical with those of the corresponding layers in the original banded sediment. As a side-line to this topic, I should like to call your attention to two points, namely, the common preservation of banding in rocks of high metamorphic grade and the equally common destruction of banding in rocks of low metamorphic grade. I would put the question as to whether a progression from unaltered banded sediments through rocks of the epizone into rocks of the higher-grade zones is always requisite. I suggest that many high-grade banded gneisses have missed some of the lower stages in their formation.

(2) An equally important process in the production of banded gneisses is that connected with igneous injection. It is becoming increasingly clear that metamorphism on a regional scale is accompanied by the injection of material of magmatic origin, usually granitic in character. This is especially evident, of course, in the rocks of high metamorphic grade. The great injection-complexes of Scandinavia, Scotland, the Alps, the Pyrenees, United States and elsewhere, supply abundant evidence on these points. A very important group of banded gneisses, therefore, is that of the so-called injection-gneisses.

In this connexion, I should like to hasten to express my opinion that we incline to emphasize unduly the importance of the so-called lit-par-lit injection as a cause of banding in injection-rocks. While I agree that late plane injection of 'magmatic' material along planes of weakness,—foliation-planes, fracture and joint planes—does give rise to banded gneisses, still I hold that gneisses arising by such a process are relatively insignificant in the whole body of banded injection-gneisses. In the case of granitic injections, such introduced lits may be recognized by the development of selvages of enlarged biotite or hornblende adjacent to the incoming quartzo-feldspathic layers.

The main process operative in the formation of the injection-gneisses is, I believe, one of replacement or metasomatism. This is no new idea, for it is inherent in the classic work of Michel-Levy and Lacroix on the French complexes, of Clarence Fenner in the United States, of Hugh Miller Junr. in Scotland and of many other observers in divers districts. My own work in the great Sutherland complex in the Northern Highlands of Scotland has shown me that a great deal of the injection-process is carried on not by discrete injection of igneous material but by a permeation of the country-rock by solutions derived from an external source, presumably an igneous reservoir. In the Sutherland complex, we can demonstrate the passage, *along the strike*, of sedimentary rocks of various kinds into injection-gneisses and migmatites. Permeation-gneisses and biotite-rich augen-gneisses arise from pelitic rocks, augen-gneisses from semipelitic rocks and hornblendic augen-gneisses from banded hornblende-granulites. Apart from the microscopic evidence, which is abundant and clear, it is evident from the preservation of the original attitude of the detailed succession of the country-rocks when they are involved in the migmatite zone that we are dealing with a pseudomorph, as it were, of the country-rock in migmatitic material. The preservation of the plane-banded sedimentary attitude in rocks now consisting dominantly of 'granitic' materials points unquestionably to the operation of igneous metasomatism. Country-rocks of different compositions react with the advancing solutions in different ways and to different degrees. The result is the production of a multitude of banded gneisses whose detailed characteristics depend upon their original composition and the stage reached in the metasomatic process at any given place.

To sum up, therefore, banding in gneisses depends fundamentally on a banding, usually sedimentary, in the original rock. This original banding is either preserved by recrystallization or it controls the formation of banded gneiss in injection-complexes, in which differential metasomatism plays a predominant part.

VI. THE SIGNIFICANCE OF BOUNDARY FAULTS IN THE SUB-HIMALAYAS.

(*Section of Geology.*)

1. Mr. P. Evans, Digboi.

The sub-Himalayan zone of the outer Himalayas in the Simla, Dehra Dun, and Naini Tal region is made up of a long narrow belt of Tertiary (mainly Miocene and Pliocene) rocks. The beds have a general northerly dip, and are separated from the older beds to the north by a thrust-fault. Within this strip it is usual to find the newer beds to the south and the older to the north, the apparent contradiction being explained by the presence of nearly parallel strike faults.

A hypothesis developed by Middlemiss, following up a suggestion of Medlicott, postulates that the main fault to the north, and to a lesser extent the smaller faults within the Tertiary strip, are 'boundary faults' marking very closely the original limits of deposition of the successive

groups. This hypothesis supposes that to a large extent the faults were successive, and not contemporaneous.

This conception of ' boundary faults ' is still accepted as the orthodox interpretation of the structure and stratigraphy of the sub-Himalayan zone.

Hayden and Pascoe have applied this hypothesis to the Naga Hills structure in Upper Assam, and have regarded the conditions here as analogous to those in the sub-Himalaya. Suess, Wadia, and others have suggested that the Naga Hills structure represents the continuation of the Himalayan folding beyond the Assam Valley syntaxis, comparing this feature with the Jhelum Valley syntaxis at the other end of the Himalayas. This appears to be a very probable interpretation.

Detailed mapping in Assam has shown that the Disang thrust-fault of the Naga Hills is not a south-eastern limit of deposition as suggested by the boundary fault hypothesis. A rejection of the hypothesis in one area, even if closely related, does not necessarily invalidate its application elsewhere, but it does undoubtedly point to the need for re-examination of the evidence on which the hypothesis is based.

The main argument in support quoted in the Manual of the Geology of India is that ' if the many thousand feet of tertiary strata found south of the fault had been laid down in a continuous sequence previous to its formation, they must have extended far to the north of it, and it is almost impossible to understand how they could have been so completely removed as to leave no trace of an outlier ' but this does not appear to accord either with modern ideas of the degree of denudation of the Himalayas, or with the results of recent mapping near Simla and elsewhere, and the object of the discussion is to consider the evidence for and against the accepted interpretation of the boundary faults.

The rival conceptions may be summarized :—

(*a*) the faults are mainly successive (that is, were formed at the end of the period during which the sediments immediately to the south were deposited) and mark approximately the limits of deposition of successive beds.

(*b*) the faults are in the main of post-Miocene age, largely contemporaneous, and have no close connection with the limits of deposition of the Eocene and Miocene beds.

It seems impossible to obtain any clear picture of the mechanism of the Himalayan mountain building movements until such a fundamental contradiction is resolved.

2. Mr. D. N. Wadia, Calcutta.

Geotectonic work in the Punjab Sub-Himalayas has helped to define the real boundary of the Himalayas, i.e. the limit of the geosynclinal deposits against the epicontinental and fluviatile deposits laid down on the marginal foreland and which have been involved in the later subsidiary phases of upheavals. This boundary is a well defined thrust-plane or zone of thrusts bringing the Himalayan Palæozoic to Eocene rocks into juxtaposition with the Miocene and later Piedmont deposits (Murree and Siwalik). The term ' main boundary fault ' applied to this fault is clearly a misnomer.

South of this thrust-plane there are a system of more or less parallel reversed faults of remarkable persistence from east of the Jhelum in Punjab to beyond the Ganges. These may be the true boundary faults, i.e., limits of deposition of successive zones of Upper Tertiary strata as much as tectonic dislocations, possessing the characteristics, structural as well as stratigraphical, ascribed by Medlicott and Middlemiss to these remarkable lines of demarcation in the Sub-Himalayan Tertiaries. These ' boundary ' faults are highly characteristic and constant features of the Punjab, Kumaon, and Garhwal Siwaliks, exhibiting the relationship commonly ascribed to them, viz., that each zone, as it follows the next

one, contains a younger Siwalik stage as its oldest rock-group. It is only at the western and eastern ends of the main Himalayan arc that the characteristics of the boundary faults change and that they cease to be original limits of deposition marking the southwardly advancing foot of the Himalayas at the successive uplifts.

The remarkable observations made by Mr. P. Evans in the Assam ranges show the absence of typical boundary faults at this end of the arc. Similarly in the Kashmir foot-hills at the west extremity these parallel lines of faults are observed to die out and to be replaced by simple fold-axes, or normal faults, which do not possess any significance as boundary faults or limits of deposition.

The old conception that the faults mark cliff-faces of the southern front of the Himalayas, against which piles of sub-montane sediments were laid down could only be true in a very limited and general sense at the most typical localities.

Tectonically these faults-cum-limits of deposition should be regarded as having been caused by the sagging of the north rim of the foreland at successive epochs of uplift of the Himalayas to form the complementary Gangetic depression at their foot. The sinking of the Indo-Gangetic trough must have been in stages, probably correlated to the orogenic pulsations, each stage marked by a fault-plane, giving rise at the surface to the features associated with boundary faults.

3. Mr. J. B. Auden, Calcutta.

Mr. J. B. Auden began by describing the work of Medlicott and Middlemiss in connection with boundary faults, and then discussed their conclusions in the light of evidence collected during recent surveys. Certain boundaries, which were thought to mark the limits of present distribution of rock groups, were considered by Medlicott to have been topographical features which originally determined the limits of deposition. This idea implies that those strata which are now absent from regions of elevation were never deposited there. These views have been found to be untenable with regard to the Nummulitic and Dagshai beds, which crop out further north within the lower Himalaya than was formerly supposed, frequently occurring as inliers below thrust sheets. There can be no question of such boundaries with the overlying thrust sheets being original topographical features. L. M. Davies has recently suggested that the Upper Ranikot sea extended from near Lhasa to Bagdad. Even accepting the original premises of Medlicott and Middlemiss, two of the so-called boundary faults of Hazara do not warrant their designation as such.

Medlicott was unwilling to admit of anything more than local and unimportant movements along the margins of his supposed elevations. Middlemiss and later workers have realized that great faulting must have occurred. More recently there has developed the conception that these faults are in the main thrusts, and that the movements along them had a considerable horizontal component.

The idea of faults developing and moulding topography in such a way that deposition becomes limited to the downthrow side is no longer a valid explanation of the position of the older Tertiaries occurring below the major overthrusts within the Himalaya. The great overthrusts were probably just post-Murree, and it was probably not until these had formed, and the tectonic units thus piled on each other had begun to rise as a mountain chain, that the geography of northern India began seriously to be modified. Once the mountainous region had formed it may be supposed that there were effective limits to the deposition of the young orogenic sediments (Siwaliks) both in the north, in Hundes and the northern slopes of the Kun Lun, and in the south, along the southern flank of the Himalaya. In as much, however, as the faults marking the present surface limits of these late Tertiary rocks are inclined thrust planes, it follows that the actual limits of deposition must lie northwards, below the overthrust units.

4. Prof. P. G. H. Boswell, London.

Professor P. G. H. Boswell found himself in the position of the passing Irishman who asked 'whether this was a private fight or might anyone join in'. As an outsider he (the speaker) with the humility born of ignorance failed to understand the raison d'être for the discussion. He could not recall a similar discussion on the question as to whether a boundary fault divided off the Alpine or Carpathian mountain masses from the adjoining basins of deposition. There were, of course, 'boundary faults', but they changed in position in successive phases of Alpine mountain-building, with the result that later movements caught up and included within the main mountain-mass sediments derived from erosion during earlier phases of uplift. He gathered that Tertiary sediments were similarly found on the Himalayan side of the boundary faults.

VII. THE TEACHING OF GEOGRAPHY IN INDIA.

(Section of Geography and Geodesy.)

Dr. Chatterjee in his opening speech said that Geography was the most neglected subject at present in India. In support of this he pointed out that of the hundreds of colleges affiliated to the 18 universities only five or six colleges teach Geography in B.A. or B.Sc. course and only one provides facilities for the study of this subject in the M.A. course; whereas it is a quite different tale in the foreign universities which not only provide immense facilities for the study of that subject on a very high standard but also for training teachers in Geography. In the opinion of Dr. Chatterjee Geography is still taught in old discarded way by untrained teachers who are lamentably ignorant of the real Geography. As a result of that, boys only get by note names of some cities and towns and some definitions of geographical terms, which is no geography at all.

In his healthy and thoughtful suggestions, Dr. Chatterjee told that in primary school and in the lower forms of the secondary school, Geography should be correlated with that of hand work, nature-study and history, in as much as nature study lessons mainly mean the observation of plant and animal life and of physical environments of the children, which, again, are the stepping stones to the study of geography. In fact, the primary object of the teacher would be to awaken children's interest in their immediate surroundings by arranging geographical excursions. In the higher forms of secondary schools and in the advanced course in geography at the university stage, Dr. Chatterjee said that geography should be taught as a separate branch of science only by those trained teachers who had a clear knowledge of the proper aim and method of modern geography; otherwise this subject would run the risk of being side-tracked by other sciences.

Lastly he suggested that a circular letter would be drafted and sent under the signature of the eminent Geographers present in the Conference to all universities, stressing the importance of geography and requesting them to provide facilities for the higher study of Geography. And geographical associations would be formed in every province with a view to creating public opinion in favour of geography.

He hoped that after such provincial associations have come into existence, a central organization with a central museum can be formed that would help schools and colleges in various ways.

After this a lively discussion followed and a large number of delegates participated in that. Miss Mary W. F. Waddington of Madras pointed out several difficulties that hampered the teaching of geography in different types of schools. In her opinion syllabus for geography is not properly

drawn out; some where it was stereotyped, some where it was too extensive.

Messrs. George Kuriyan and S. M. Ayyar of Madras stressed the need for entrusting that subject only on the trained teachers for teaching so that the subject might be properly handled; the latter put in a strong plea for the general recognition of the importance of study of local geography at all stages.

Mr. C. Raghunatham of Madras suggested that geography should be taught in elementary schools as that formed the real foundation for the study of the subject at all the higher stages.

Mr. A. N. Basu of Calcutta divided the problems of geography teaching into three classes:—(*a*) paucity of the right type of teachers, (*b*) paucity of materials, and (*c*) paucity of good text books. Dwelling on the third problem, Mr. Basu said that most of the text books were written from the standpoint not of Indian students but of students of other climes and countries. This sort of text books, in his opinion, makes the subject an unreal one. He laid emphasis on the fact that geography should be taught entirely from the standpoint of the Indian students, so that the subject might be well grasped by students.

Mr. A. K. Banerjee of Calcutta endorsed the view of his previous speaker about the need for good text books. He deplored the paucity of materials in high schools of Calcutta which hindered a great deal the teaching of geography on the modern line. In his opinion, geography teachers should be geography-minded and this would be possible by opening geographical societies in different parts of the country.

Miss Gasper of Calcutta put in a strong plea for plenty of out-door work, use of one inch maps and nursery rhymes and this would inspire the boys to use their powers of observation in the study of physical and the human aspects of the Home Region.

Dr. L. Dudley Stamp of London opined that the basis of the whole trouble is that there is movement in a vicious circle, which has to be cut down somewhere. In his opinion, if the teaching of geography in schools be improved, there will be considerable improvement in the teaching of geography in colleges. In the actual teaching of the subject, he said that the teacher of geography has to keep to himself the purpose of geography and the logical sequence of it and only then text books can be made interesting and real.

Mr. N. Subrahmanyam of Madras in rounding off the discussion was at one with Dr. Stamp in his view and added that progress should be made all along the line in order that it may be effective and permanent. He opined that university authorities should be persuaded to take immediate steps to provide facilities for the study of geography and give requisite training and insist upon the right qualification for the teacher of geography, while it is incumbent on the geographical associations to create the proper public opinion.

VIII. ANIMAL ECOLOGY IN RELATION TO INDIA.

(Section of Zoology.)

A discussion on 'Animal Ecology in relation to India' of the section of Zoology was held in the Zoology room (Chemistry Room I, Presidency College, Calcutta) on the 4th January, 1938 at 10-30 A.M. under the chairmanship of the President of the Zoology Section, Prof. G. Matthai.

1. Prof. P. R. Awati, Bombay, opened the discussion.

Ecology is a new name for the old subject, Natural History. The old Natural History methods are now looked upon with some disfavour, since they aimed mainly at the collection of specimens. With few exceptions (e.g. the Bombay Natural History Society), local Natural History Societies, however much they catered to the popular interest, do not seem to be of service to modern Ecology.

Ecology is scientific natural history that attempts to explain the physiology of organisms. It is a disciplined study of organisms in relation to environmental factors such as light, air, water, soil. It is the study of the action, and reaction between organisms and their environment, as well as among the organisms themselves.

India is perhaps witnessing the last phases of the old Natural History. There are several Natural History Societies and Museums in India whose collections are often ill-assorted, ill-classified, badly preserved and wrongly labelled, to be of any scientific use. Ecological investigations are sometimes conducted by those interested in the applied sciences. In departments such as Agriculture and Medicine, for fighting pests of crops, and germs of disease.

Ecology has not yet found a place in the curriculum of university studies, although in western countries attempts are being made to give it a place in university syllabuses. Julian Huxley would like (so would we) to see some of the new subjects such as Animal Ecology, Developmental Physiology (Entwicklungs Mechanik), Genetics, Animal Behaviour, taught side by side with the old traditional subjects, Comparative Anatomy, Physiological principles, Cytology, Histology, Evolution and Systematic Zoology.

Students who take a post-graduate degree by an examination only should be required to study the principles (elementary, of course), of these new subjects, in addition to an advanced study of the fundamental branches of Zoology, whilst those who are required to do some research work in addition to a written examination would be well advised to undertake ecological investigations. When, however, a graduate degree is sought solely on research, an ecological thesis might not be regarded as 'safe' for that purpose.

2. Prof. C. R. Narayan Rao, Bangalore.

The distribution of Batrachians in Mysore.

The plateau of Mysore surrounded on three sides by mountain ranges and by level plains towards the east, is diversified by physical characteristics such as heavy forests and hills raising into bare crags in the higher altitudes, and level plains deriving their character from the means of water supply and the nature of the soil determining the cultivation. The fauna of the country especially towards the west is, in richness and variety, comparable with that met with in Malabar and Travancore.

The tropical forests present a vertical series of strata available for animal occupancy, and the inhabitants of these areas are distinguished by certain well-defined morphological features. These adaptative modifications are closely correlated with the physical conditions of existence, such as humidity, air movements, light and leafy covering of the ground area and the nature of the soil. The trees and shrubs which provide shelter may be classified under the following heads: (i) trees extending here and there up to 80 ft., (ii) lower tree tops, from 40 to 50 ft., (iii) small trees, 20 to 30 ft., (iv) higher shrubs, above 10 ft., and (v) forest floors and low shrubs.

The leafy canopy casts a heavy shade, preventing grass from growing in the deeper recesses of forests, and here the deciduous leaves preserving moisture and warmth, provide protection. The temperature in the deeper

regions of the forests is comparatively high, ranging from 100 to 115° F. while in the margins of the forests the temperature rarely exceeds 100° in the hot weather.

The warmth of the air saturated with moisture makes the tropical forest of the Malnad area a paradise for tailless amphibians. Generally speaking they are slender in build. They are almost entirely of arboreal habit, a few are rupicolous, so much so that, except during the breeding season, they rarely descend. In accordance with such habits, we find that the digits are provided with extensive adhesive discs with aborted web. A few Batrachians build leafy sacs on branches overhanging the water for depositing their eggs in, so that the larvæ fall into the water on hatching.

If we travel from the plains towards the Malnad area, we find there is a marked contrast in the distribution of the several families and even the members of the different genera. Certain species belonging to the genus *Rana* are absolutely plain-dwellers, not represented in the Malnad or in the margins of forests or in the higher altitudes, though a few hardier species may be found even on the tops of the bare crags. In the margins of the forest the principal genera are *Nyctibatrachus, Rhacophorus* and *Philautus.* The latter genus is entirely absent from the plains. In the plantations which have sprung up near the margins of forests, a large number of *Engystomatidæ*, principally of the genera *Ramanella* and *Microhyla* are represented. Curiously they are also arboreal while their congeners in the plains are burrowers, a habit of life which has produced remarkable morphological variations. The structure of the skin is equally interesting, inasmuch as the dermis possesses large spaces for the retention of water, a provision against the extreme dryness which prevails during the hot weather.

The paper gives an account of the distribution of the Batrachians in accordance with the physical variations of the country, and describes the morphological adaptations produced by climatic and other ecological factors.

3. Dr. Sunder Lal Hora, Calcutta.

Animal ecology of torrential streams.

The author explained how the ' association ' of a torrential fauna could be grouped into well-marked 'habitats' which could be further classified into a number of ' strata '. The physical and biological conditions which influenced the distribution of animals into ' niches ' were discussed and it was shown that the presence of an organism in a particular type of environment was not a chance occurrence, but was the result of an adjustment of the animal to the external conditions of its existence. By a series of examples, taken both from the vertebrate and invertebrate fauna of rapid waters, the author illustrated that this close adjustment of an organism to the external conditions of its existence or ' adaptation ' was brought about through a series of gradual changes in the build of an animal which were, in the main, induced by a number of factors composing its environment. It was concluded that for the study of organic evolution and adaptation it was of the highest importance that animal structure should be thoroughly analysed in terms of its environmental factors, and by such an analysis all chances of confusion arising out of a similarity of structure under apparently different conditions or of a divergence of structure under apparently identical conditions would be eliminated.

4. Dr. H. Srinivasa Rao, Calcutta.

Ecology of animals living in brackishwater areas of India.

The term ' brackishwater ' is restricted to such areas of water as have permanent or temporary communication with the sea by estuaries

of rivers, or of channels connecting marshes, swamps, and backwaters on the coasts of the Indian Empire. The waters of the areas under consideration are very variable in salinity throughout the year due to the rise and fall of the tides, or to the periodical influx of freshwater from floods and rainfall during the rainy seasons. Certain inland streams and lakes, the high salinity of which is due to purely local causes, as for instance in the streams of the Punjab Salt Range and of Seistan, are excluded from the meaning of the term 'brackishwater'.

The brackishwater fauna of the Indian Empire is as yet little known, but certain typical areas such as, for instance, the Gangetic Delta and the Calcutta Salt Lakes, and the Chilka Lake have been more fully investigated than the others. Preliminary surveys of the fauna of the Vizagapatam, Ennur, Adyar, Travancore, and Cochin backwaters, all of them in S. India, have yielded results not unlike those obtained for the Gangetic Delta and the Chilka Lake, but no detailed observations in regard to the ecology of animals constituting the fauna have as yet been made.

The main types of environment in brackishwater areas may be enumerated under the following heads :—

1. The bottom—of mud, sand, or rock.
2. The inter-tidal region—of mud, mangrove or rock.
3. The weeds—consisting of flowering plants and algæ.
4. The mid-water.
5. The surface-water.

The groups of organisms that are associated with these types of environments are considered. They are of mixed origin—some being marine and some brackishwater, others being freshwater. Certain species of animals are periodical immigrants when salinity conditions are favourable. They die out when they are no longer able to withstand marked and sudden changes in salinity. Certain other species which are well adapted to changing conditions of salinity become the permanent inhabitants of the areas. These are usually of brackishwater origin.

The causes of migration of marine as well as freshwater animals from their habitual environment into brackishwater areas are analysed.

The conditions of life in brackishwater areas, particularly as regards availability of food, competition from various animal species, temperature, chemical and physical conditions, are considered.

5. Dr. H. S. Pruthi, New Delhi.

A brief review of the work on the influence of the chemical and physical conditions of water on the bionomics of freshwater fauna in India.

The freshwater fauna of various tropical countries have received considerable attention during the last 40 years, but most of these studies are of purely systematic character. Many problems with regard to the biology, distribution and mutual relationships of the components of various faunas yet await solution. It is now widely recognized that the most essential work preliminary to the solution of such problems is the thorough study of the environments under which the various animals live. Whereas the fresh waters of the temperate region of the world have been exhaustively studied from this point of view, those of the tropics have yet received very scanty attention. Less than a dozen workers distributed over South America, East Africa, India, Ceylon, Java, Sumatra, Bali, etc. have yet investigated the chemical and physical conditions of tropical freshwaters and the influence of these conditions on their faunas. The workers in other countries who have made important contributions to this subject are P. Van Oye, Apstein, Worthington, Carter and Beedle, Ruttner, etc.

In India Senior White, Hora and Pruthi have been engaged on this line of work. Senior White studied the distribution of mosquitoes in

relation to the nature of waters in Ceylon. Hora has paid considerable attention to the physical conditions of rapid waters on fish and other animals in several parts of India. Pruthi critically examined the seasonal changes in the conditions of the Museum tank in Calcutta and studied their rôle in causing periodic epidemics of fish mortality in that water. He also investigated the conditions of life in the highly saline waters of the Salt Range, Punjab. A brief account of the results of important works of these authors will be given.

6. PROF. R. GOPALA AIYAR, Madras.

Marine biological research in India with special reference to plankton, and growth and reproduction in marine animals.

Early marine biological research in India is bound up with the work of Alcock, Annandale and Sewell as Surgeon Naturalists of the R.I.M.S. Investigator or as Directors of the Indian Museum, Calcutta. The investigations of Herdman in connection with the pearl fisheries of Ceylon, of Gardiner and others on the fauna of the Maldive and Laccadive Archipelagoes have greatly added to our knowledge of the marine fauna of the Indian Coast. It may be said that systematic Plankton work has not been attempted in India. Various organisms, however, which form constituents of Plankton have been the subject of intensive studies amongst which Col. Sewell's work on the Copepods and the Salpa of the Indian Seas, the work of Doncaster, Browne, Stiasney and others on Sagitta and Medusæ of the Arabian Sea may be mentioned. In recent years a fair amount of work has been done on Plankton and Planktonic forms on the Madras Coast. A comparison of the Plankton of the Irish and the English Seas with that of the Madras Coast is instituted and it is shown that here the Phytoplankton shows definite seasonal maxima. A comparison is also made with the Plankton of the Australian Coast. The influence of sunlight, temperature, salinity and chemical constitution of sea water on Plankton is briefly discussed.

Investigations regarding the periodicity in breeding of tropical animals of the Indian Coast may be said not to have been attempted at all. With the exception of the work of Herdman and Malpas on the pearl oyster and the work on Trochus by Rao no detailed published account exists on the behaviour of tropical forms in regard to breeding in Indian waters. Recently (yet unpublished) work on a number of sedentary organisms growing in the Madras Harbour goes to show that the views of Semper, Orton and Mortenson regarding the breeding of tropical animals cannot be taken as altogether correct. Evidence is available to show that breeding in the Madras Coast is very similar to that of the Great Barrier Reef. It may be said that the breeding of animals in the tropics may be grouped under five definite heads. 1. Single breeding period not lasting the whole year round. 2. Continuous breeding all year round but more active during certain portions of the year. 3. Continuous breeding throughout the year without any marked breeding in any part of the year. 4. Two breeding periods in an year with a quiescent phase in between. 5. Discontinuous breeding related to the phases of the moon. Work done here is in almost complete agreement with the results obtained by the Great Barrier Reef Expedition.

Regarding growth and attainment of sexual maturity the data gathered from the Madras Harbour, taken in conjunction with the information available on work of a similar kind carried out in other parts of the world with very similar climatic conditions, show that sexual maturity is attained at an astonishingly early period and several broods are produced during the course of the year. The rate of growth here is found to be extremely rapid as compared with forms in other parts of the world.

7. Prof. B. K. Das, Hyderabad.

Animal Ecology with special reference to the evolution of the Indian air-breathing fishes.

The following points were discussed by the author :

1. The various types of ecological conditions existing in India and other tropical countries, and their relation to the characteristic features of the faunas found in such localities.

2. Main factors responsible for the evolution of the air-breathing habit :—

(*a*) Lack of oxygen in shallow waters is the main stimulus for the instigation and development of this habit, and is of the greatest bionomic importance.

(*b*) Other environmental factors associated with pools and ditches (stagnant waters), swamps, rivers and streams, lakes and seas, littoral and other zones.

3. Various kinds of adaptations leading to structural modifications as correlated with ecological conditions. As a rule the adaptations are quite new, distinct and of independent origin, but in a few cases they may represent a single phylogenetic type.

4. Certain general characteristic features of the air-breathing fishes —cf. similar environmental conditions prevailing in different parts of the world have led to identical physiological adjustments—a very interesting case of ' parallelism in evolution '.

5. If an organ is modified for aerial respiration it must have (i) air passing in and out of that organ, and (ii) have a capillary net-work—both these conditions are being satisfied by the accessory air-breathing organs.

6. The accessory respiratory organs are chiefly an adaptation for the absorption of oxygen from the atmosphere, whereas the gills form the main seat for the excretion of CO_2.

7. In the evolution of air-breathing habit, as a direct reaction to the low concentration of oxygen in the surrounding medium, there is clear evidence of a change of function, followed by structural modifications.

8. Air-breathing habit is the starting point for a series of adaptations that must have helped migration to land, and is a prelude to the whole sequence of later changes that must have led to the evolution of higher vertebrates.

9. Lack of oxygen in tropical waters must have played a most important rôle in the evolution of the terrestrial vertebrates—it is generally believed that the emergence of these vertebrates must have taken place in some such environment, viz., shallow tropical fresh waters or swamps (in other words, semi-aquatic habitat) exposed to occasional droughts.

8. Dr. S. C. Law, Calcutta.

Ecology of avifauna in India.

The correlation between the geographical environment and different forms of life, which is so readily observable among plants, holds good in the case of the avifauna of India as well. The subject, however, has only begun to be investigated, and not more than a few pioneer studies are available.

The scope of the paper is limited to certain ecological facts concerned with the avifauna of two particular regions, viz., Lower Bengal and the Himalayan region round about Darjeeling, which came under the investigation of the writer.

Lower Bengal is a deltaic region and has all the characteristics of a delta. The Darjeeling region, on the other hand, is composite in its

geographical character and presents features common with tropical or sub-tropical regions at lower elevations, and temperate and sub-alpine characters at elevations ranging from 5,000 feet upwards. These environmental features are also reflected in the avifauna of each of these two areas. The Darjeeling area with its diversified ecological zones harbour a varied avifauna ranging from the forms peculiar to the plains to those specially adapted to high elevation. The plains species like the Shama (*Kittacincla malabarica indica* S. Baker), the Racket-tailed Drongo (*Dissemurus paradiseus grandis* Gould), Harewa or the Goldfronted Chloroposis (*Chloropsis a. aurifrons* Temm. & Laug.) and the Hill Mynah or Grackle (*Gracula religiosa intermedia* Hay) have their habitat in the low-lying belt surrounding the foot of the hills, seldom exceeding a few hundred feet beyond it. The birds of the temperate zone on the other hand roughly populate an area from about the height of Kurseong to an elevation little over 1,000 ft. above the town of Darjeeling. Among the characteristic vegetation of this zone, the mantle of mosses and fernlike growths harbour plenty of insect food for the birds and also provide nesting material and sites. After this comes the zone of the palæarctic birds, the borderland between which and the temperate zone is the haunt of an admixture of palæarctic and oriental or Indian types.

In Lower Bengal the environment of marshes and *jheels* is congenial to wading birds of the family *Rallidæ*. The areas under tillage are inhabited by a different type of avifauna or rather society or association of birds. Of the waders Snipe with its smaller congeners prevails in the low-lying areas. Larks with Pipits are found in the meadow lands and higher cultivated fields. Plovers and Lapwings are no less a feature of these surroundings. Cattle Egrets are a necessary concomitant of the cultivated fields. The backwaters and salt-impregnated *khals* and *bils* harbour Terns and Gulls. Kingfishers appear to prevail everywhere, and so do Doves, Babblers, and Cuckoos. But on scrutiny particular species are found peculiarly attached to certain environments.

Lower Bengal falls directly in the migration route of birds from north to south and *vice versa*, and while it receives the influx, the stream divides somewhat longitudinally when an outpour into the Indo-Malayan region commences simultaneously with a convergence of avine sojourners to Central India. This accession of avifauna, though noticed haphazard at first, readily plants itself in its proper setting. The ornithologist familiar with environmental factors will at once locate the associations that grow up in different settings. The Ducks and Geese arrive in legions, but what for their nocturnal habits and what for their undertaking migration only at nightfall they compel their adjustment without commotion to their habitat or surroundings. The Sunderban areas harbour them in large numbers, and while they still abound in some congenial river-banks elsewhere, their number continues to dwindle appreciably due to diverse causes mainly affecting their environment.

9. DR. B. SUNDARA RAJ, Madras.

Ecological Research with particular reference to Indian fisheries.

In most fisheries man simply gathers a wild harvest, without in any way contributing to its creation. Fish therefore live and die in their natural environment and so provide a rich field for the ecologist. The reactions of fish to physical, chemical and dynamic conditions in the sea and fresh water to soil and bottom material, their response to weather and climate, their food habits and life history as adapted to their environment, and finally their adjustments as communities to other aquatic life including a statistical study of their relative abundance, form the bulk of fishery research which is essentially ecological in character.

The basic problems of Fisheries all over the world may be grouped under four heads:—

1. Can accurate estimates of the productivity of fisheries be made ?
2. What possibilities are there of extending fisheries to new grounds or of augmenting the production of existing grounds ?
3. What, if any, protective measures are needed to prevent depletion of a fishery or to restore a fishery that has declined ?
4. Can a rational basis be found for forecasting the success or failure of a fishing season so as to order the efforts of the fishing industry to maximum advantage ?

The last two problems at present have little more than an academic interest for us in India, as so far our sea fisheries have only been feebly exploited and the potentialities of the deep sea are practically unknown, while as yet little is known of the biology of our food fish. Studies on the oil sardine, the most important commercial fish of the Malabar Coast, tend to throw light on the causes of the great fluctuations in this valuable fishery but as yet we are a long way from being able to forecast accurately the probable annual fisheries in India as has been done successfully in Europe and America during the last decade. We may therefore confine our attention to the two first questions.

1. Can accurate estimates of the productivity of fisheries be made ? The wide investigations made in recent years since the inauguration of quantitive methods in Marine Biological Research by Henson, have proved that the productivity of the sea and fresh water may be greater than that of land per unit area. Leading authorities have held the view that seas which are relatively deficient in plankton, as Tropical waters are declared to be, must be poor in fish. Biological and fishery investigation in Indian seas point to quite a different conclusion. Statistics are available for the West Coast of the Madras Presidency since 1925.[1] The average quantity of fish landed by a fisherman works out at seven tons in a poor year, taking the 1921 census as a basis. For the same year 1925 the Japanese fisherman landed on an average three tons and the Scottish Fishery Report for 1926 gives over twelve tons per fisherman.[2] If the Malabar fisherman with his primitive methods, afraid to go out of sight of his hut, can capture in a poor year more than 50% of the quantity caught by Scottish fisherman, using the most powerful and up-to-date methods and vessels, and able to choose the most profitable fishing grounds, it must be admitted that the Malabar Coast is at least as productive as the best waters open to Scottish fishermen.

Experiments made with trawlers between 1900 and 1930 in Bombay,[3] Ceylon,[4] Bengal [5] and Madras [6] point to the same conclusions. Though the hours of work and the classification of fish caught were not the same for the different trawlers, the results have been reduced more or less to a uniform basis. Catches in Indian waters vary from 19·04 cwts. to 68 cwts. per day's fishing. Corresponding figures for a day's absence from port for English trawlers in 1921 range from 14·62 cwts. to 49·31 cwts. Had Indian trawlers been worked on commercial lines the catches would have been larger. In calculating total catches by trawling, it must be recognized that the more northerly bottom-feeding fish, cod, hake and haddock, and the flat fish, plaice and halibut, which support the great commercial fisheries of Europe and America, are either totally absent or represented by uneconomic species. In India trawl fish consist mostly of sea-perches, jew fish, thread-fins, sea breams, cat fish, sharks, skates and rays. The well-known table fish, such as the various species of seer, mackerel, pomfret, herring and sardine, are mostly surface or midwater fish, and are not usually captured by trawls. Until fishing with seine and drift nets has been done in deep water the total productivity of Indian seas cannot be correctly estimated. In-shore fishing and trawling however have proved the productivity to be equal to that of colder waters, and it is safe to assume that surface and midwater fish in off-shore waters

will also prove to be equally abundant. The Imperial Economic Committee in their report on fish dated 1927 say, 'It is probable that the chief difference is that in the warmer seas there are many more kinds of fish and probably fewer individuals of any one kind'. The rapid metabolism of Tropical species [7] also probably contributes to increased productivity. Most fish in the Tropics breed when they are a year old. The eggs of the Indian shad hatch in 16 to 24 hours while the American shad usually takes 6 to 10 days.[8] Growth in the sub-tropical Californian sardine, *Sardinops cœrulea* is estimated at only 7·9 mm. a year,[9] while the Indian *Sardinella longiceps* reaches 15 cm. in the first year.[10] It has been recently ascertained that the Indian shad (hilsa) grows to 22 cm. in 9 months.[11] In German ponds carp grow at the average rate of 1 lb. per year; in the warmer parts of the U.S.A. at 3 lbs., but a growth of 1 lb. in 70 days is on record for Indian carp. The average annual yield of carp ponds in Europe is 1 cwt. per acre. In South India it is 1,000 lbs. per acre,[12] and with hand feeding may reach 3,500 lbs. per acre.[13] Rapid reproduction and growth may easily account for increased output per unit area, even though the number of fish of any species at a given time may not be as large as in temperate and Arctic seas.

2. What possibilities are there of extending fisheries to new grounds or of augmenting production of existing grounds? The major fishery investigations conducted in India and Ceylon come directly under this category. All the trawling experiments in Indian waters were for the purpose of establishing a deep sea trawling industry. The question of extension, however, is complicated by the possible effects on the existing inshore fisheries, and the disentanglement of the complex problems involved falls directly within the province of ecology.

Our pearl fisheries, which, unlike all other pearl fisheries, occur only in irregular cycles of years [14] present economically important ecological problems, as yet unsolved after nearly a hundred years of research in Ceylon and India. In 1921 there was a sudden and unaccountably large spat fall, though the pearl banks both on the Indian and Ceylon coasts had no oysters worth mentioning in 1920. The nearest outside sources are the Persian Gulf and the Mergui Archipelago, but no spat could travel so far during their short life as pelagic organisms and if they did would surely have left some trace of their passage along the East and West coasts of India. The only reasonable conclusion is that they were bred locally. Hornell suggested the presence of mother oysters in the coral reefs skirting the coast,[15] but after a careful search oysters on the reefs were not found in appreciably larger numbers than on the banks themselves. All other explanations having failed the only other possible source was considered to be mother beds in deeper waters, that is, beyond the reach of naked divers in the Gulf. It is known that beds identical in structure to the known pearl banks exist in 12, 16, 24 fathoms and more on the Indian coast. A careful survey of the continental shelf on the Indian side of the Gulf of Manaar was suggested to the Madras Government but has not so far been carried out for various reasons. So far a bank of young oysters located in 16 fathoms by a preliminary exploration by the Fisheries Trawler 'Lady Goschen' is the only evidence in support of this hypothesis. Great fluctuations and the occasional prolific years of reproduction are due to a fortuitous combination of favourable factors. The presumption is that in such years the oyster spat invade inshore banks and yield the pearl fisheries of Ceylon and India. When normal conditions return the beds shrink back to their usual limits in deep water.

The second problem, that of augmentation of existing fisheries embraces all the elaborate technique of the pisciculturist. So far the need for the culture of the true marine fish has not been felt even in Europe and America and the only evidence of depletion of stock through human agency occurs in the whale, halibut and Pacific albacore fisheries. It is admitted that we cannot maintain any of the true marine fisheries by artificial propagation.[16] The great fluctuations in sea fisheries have been

proved to be the result of years of highly successful reproduction due to a fortuitous combination of favourable factors. The successful generation may then dominate the fisheries for several years. Thus the herring bred in 1904 dominated the commercial captures of herring in Norwegian waters from 1907 to 1919.[17] Similarly in the Californian Sardine (*Sardinops cœrulea*) four dominant year classes were noticed at intervals of two and four years from 1919-20 to 1920-30.[18] Researches on the Indian oil-sardine point to a similar conclusion. The fish caught in the abundant year 1933 were immature. In 1934-35 and 1935-36 only adult fish were caught, the average size increasing slightly in the 1935-36 year's catch. The heavy catches of 1933-34 were due presumably to the favourable spawning of the 1933 summer and the poor catches in the subsequent years to unfavourable spawning seasons.[19]

Turning to pisciculture in inland waters the exotic food and game fishes introduced into India are Brown and Rainbow Trout from England and New Zealand for hill streams, Golden Carp and Tench from Europe and Gourami from the East Indies for the Plains. The Brown Trout has done well on the Himalayas and in the Punjab while the Rainbow Trout has prospered in South India and Ceylon. All attempts to acclimatize the Golden Carp and Tench to the waters of the Plains have failed, though they still breed in Ootacamund Lake. When a suggestion was made by a practical fisherman for stocking with Trout the hill waters of the Punjab which were barren of fish of any value,[20] it met with the most violent disapproval from orthodox zoologists on what appear to be purely theoretical grounds.[21] That the introduction of exotic species should be done with care is reasonable but the objection is valid only where it applies. The introduction of trout on the Nilgiris, where the indigenous fish were of no value at all has caused no regret but has yielded a valuable and successful fishery for over thirty years. Since conditions are similar on the foothills of the Himalayas the introduction of trout is the best practical measure that can be recommended on ecological grounds. The South India and Ceylon experiment affords a concrete instance of the success of the scheme.

The highly esteemed gourami, which is well adapted for cultural treatment and has been bred in Java for centuries, is the chief exotic fish cultivated in all the fish farms of the Madras Fisheries Department. It attains the large size of 24 lbs., feeds chiefly on water plants, is boneless, and has an excellent flavour. Extensive experiments have been carried out in Madras during the last 20 years, and as it is cultivated in small ponds in Java it was assumed that it was only suitable for stocking the stationary waters of protected ponds. So it was never introduced into rivers and lakes. But a few years ago an accident occurred to the gourami pond in the Peradeniya Botanical Gardens in Ceylon when the pond overflowed into the neighbouring river. For years the fish were given up for lost, but in 1935 it was discovered that the fish had established themselves in the river, which is the largest in Ceylon, and were the object of an extensive commercial fishery.[22] The knowledge thus gained opens up great possibilities for the development of river and lake fisheries in India.

Two other exotic fish have been introduced for anti-malarial measures. They are the Barbados Millions—(*Lebistes reticulatus*) and *Gambusia affinis*.

The more valuable indigenous fish have also been made the subject of experiment. For larvicidal measures we have *Aplochilus* and *Panchax*, which have proved to be equal to any imported varieties, and being indigenous are both cheaper and better adapted for use.[23] A recent attempt was made to assess their larvicidal value by examining their gut contents to determine their natural food. As anopheline larvæ were found in only 10% of the fish examined it was concluded that these fish are not partial to a diet of anopheles and are therefore of no value as larvicides.[24] But as Dr. Gravely points out,[25] in small tanks and pools,

whenever the fish disappear mosquito larvæ are at once found, but as long as the fish are there no larva is ever seen. Evidence from stomach contents is not conclusive without more elaborate and critical tests on accepted ecological lines, while practical field experiments have proved the undoubted efficacy of these fish in combating mosquito nuisance.

Among the indigenous food fish that have been cultivated in India are hilsa, several Indian carps (*Barbus*, *Catla* and *Labeo*), an estuarine perch-*Etroplus suratensis*, and the white mullet or milk fish, *Chanos chanos*. Hilsa is a large and highly esteemed fish which ascends rivers for breeding, and extensive and valuable hilsa fisheries exist in all the important rivers of India. Since 1869 the Madras Government have been taking steps to safeguard hilsa fisheries from extinction, and the only satisfactory course was found to be a hilsa hatchery on the Coleroon river. Artificial breeding of hilsa has been successfully carried out in Madras,[26] but the problem of rearing the fry until they are sufficiently large to be liberated into the rivers still remains to be solved. An intensive ecological study of the hilsa was also undertaken and the life history of the fish in its main outlines has been traced, and their rate of growth in the rivers ascertained.[27] How long the fish remain at sea and whether they go to deep waters, when and how often they return to the rivers for breeding, are problems that remain to be investigated.

Catla, one of the largest Indian carp, is specially noted for its rapid growth in all kinds of water (except brackish) from small wells a few feet in diameter to large lakes and rivers hundreds of square miles in area. It is not predaceous and the fry will reach a marketable size of 18–24 inches in seven to eight months, for which period alone most of the irrigation tanks in the Madras Presidency hold water. The natural distribution of the fish stops with the Kistna river and so far it has not been possible to breed it in any of the fish farms. Therefore its general distribution from the Kistna and Godavari to the South of the Presidency is unusually difficult and expensive. It was found however that after the construction of the Kurnool-Cuddapah canal catla spread into the Pennar river, about 150 miles south of the Kistna. This suggested the possibility of establishing catla in the Cauvery but the proposal was condemned by some zoologists.[28] It was declared on theoretical grounds that catla are tank fish and inhabit stationary water, breeding in inundated paddy fields,[29] but as evidence to the contrary from field studies and the positive migration of the fish from the Kistna to the Pennar river systems was conclusive, the scheme was persevered with until success was attained. Eight years after the Mopad Reservoir was first stocked and nearly twelve years after the first stocking of the Cauvery, evidence became available of the success of the scheme. Catla of all sizes now appear in the catches at Mopad and throughout the Cauvery river, thus proving the soundness of the scheme.

Etroplus suratensis is a valuable food fish of the sea and backwaters which, though it normally breeds in salt and brackish waters, readily acclimatizes and breeds in fresh water if nesting facilities are provided.[30] It is now extensively bred in the Madras fish farms and is used for stocking tanks.

Chanos chanos is another backwater fish largely farmed in the East Indies. Experiments have just begun in its culture in Madras.

Pearl farming is attempted in the Gulf of Manaar. One of the aims of the Krusadai Biological station is the establishment of a pearl oyster park with the twofold object of providing spat from the park when the natural supply of oysters fails on the banks, which adjoin the park, and of inducing cultural pearls in the Indian oyster.[31] Though attempts made during the last eighty years in Ceylon and India only met with failure,[32] the experiments in pearl oyster culture begun in 1933 on Krusadai Island have succeeded. Spat transferred from pearl banks in 1933 are still alive and have grown at the same rate as on the natural banks. They have also bred and the spat produced have grown to adult size without undue

mortality.[33] An important ecological phenomenon observed contrary to all expectation was that oysters live best on mud banks if suspended about five or six feet above the mud bottom, and thrive in bays well sheltered from wind and tides, though the water may be turbid and low in salinity owing to land drainage.

The establishment of catla in the Cauvery, the accidental spread of the gourami to the lower reaches of the Mahawali-Ganga in Ceylon, and the culture of the Indian pearl oyster in shallow muddy bays in spite of theoretical objections demonstrate that academic arguments should not be allowed to outweigh the results of careful ecological studies in the field and of practical experiments. As with all other ecological research, the habits and responses of fish in their natural environment, must provide the foundation for the kind of experiment to be performed and the equipment to be employed in piscicultural experimentation. Initial facts have to be discovered by a study of the fish in Nature. At the same time if culture is to improve on Nature, new departures and a spirit of adventure must characterize experiments. Such a bold departure is no mere leap in the dark. It is wellknown that a fish may be trained to make mental associations otherwise some of the complicated migratory movements of fish especially those of the Pacific salmon, which return to their native hill streams with unerring instinct will be unintelligible. From a purely ecological point of view also, the 'biotic potential' which is the rate of reproduction, capacity for survival, protective reactions and structures found in an animal is but the quantitive expression of the dynamic power of the species, pitted against the resistance of the environment. With changes in the environment the expression or behaviour must also change.

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10. PROF. G. D. HALE CARPENTER, Oxford.

Ecology.

Ecology, after all, is only Natural History, organized, analyzed and systematized. An ecologist is born, and not made—let us make the most of those who have the gift. Prof. Awati made the sad statement that ecology is not considered a suitable subject for an advanced thesis because it often leads to no definite result. This seems to be grave indictment of a situation which should not exist.

Regarding museums the ecological aspect of display of collections is far more important for the public than the accumulation of large numbers of specimens to illustrate taxonomy, which is a question for advanced students rather than the general public. A very good beginning has been made in the Indian Museum by Dr. Prashad.

11. PROF. P. A. BUXTON, London.

Prof. P. A. Buxton (University of London) gave a short account of the growth of knowledge about the ecology of mosquitoes. In his opinion the results of many years' work were rather disappointing. He attributed this in part to the fact that the work has generally been done by men working in isolation (the subject demanding a knowledge of water chemistry and physics, algalogy, bacteriology and other matters, and being appropriate to team work), and in part to the fact that observations in the field had not been sufficiently analysed by experiments made in the laboratory.

PROFS. W. M. TATTERSALL, L. F. DE BEAUFORT, and LT.-COL. R. B. SEYMOUR SEWELL, also took part in the discussion.

IX. THE PLACE OF SYSTEMATICS AND MORPHOLOGY IN THE STUDY OF THE LIVING ANIMAL.

(Section of Zoology.)

A discussion of 'The place of Systematics and Morphology in the study of the living animal' of the section of Zoology was held under the

chairmanship of the President, Prof. G. Matthai, in the Zoology section on January 5, 1938 at 10-30 A.M. The President introduced the subject and called upon Col. Sewell to open the discussion.

1. Col. R. B. Seymour Sewell, Cambridge, opened the discussion.

The place of systematics in the study of the living animal.

A study of the live animal can be carried out along several different lines but in every case it is impossible to separate the study of the living and the dead.

Whatever branch of study one may wish to undertake, the first essential is the identification of the animal. The Systematist bases his classification on Morphology, but he is fully aware that evolution is continually going on and that the species is liable to variation. The study of Evolution necessitates the study of Genetics, Distribution and Ecology. Each branch of study is intimately correlated with other branches, and Systematics, which is based on Morphology, is the central pivot around which all other branches are grouped.

2. Prof. K. N. Bahl, Lucknow.

The place of morphology in the study of the living animal.

Morphology is an ancient study which forms the basis of orthodox taxonomy and has yielded remarkably valuable results in systematic zoology. It is impossible to study the mechanism of the living animal or its habits and relations to its environment without studying its structure as well, just as it is impossible to understand the working of a motor car without knowing about the petrol feed, the carburettor, the ignition and the transmission gear. Emphasis merely on 'topics' of behaviour, organ-systems, economic applications, etc., tends to vagueness and lack of logical unity. Structure and function go hand in hand and evolve *pari passu*.

Modern views about the anatomical basis of 'reflex action' illustrate the method of an experimental science. Excretory organs and hepatopancreatic glands of earthworms exemplify how morphological studies open up new fields for physiological and ecological work. Study of cytology and its co-operation with physiology and genetics have led to remarkable results in heredity.

3. Prof. H. K. Mookerjee, Calcutta.

The place of embryology in the study of the living animal.

Animals having similar characters are considered, on the basis of the theory of evolution, to be closely related, and dissimilar structure means distant affinities. The older systematist's task, therefore, was simple, and in building up classification he merely depended upon similarity of structure. With the advance of knowledge it became evident that similarity of structure was not the true test or criterion, and the idea of homology and analogy should be kept in mind when comparing animal structures.

Organs which are developmentally alike are homologous, and morphology, in the wider sense, thus includes science of development or embryology. I shall now cite a few concrete examples from my own investigations on the development of the vertebral column, on which I have been working for a number of years, in order to show the value of embryological evidence on animal structure. These will be in the nature of answering certain questions which naturally arise in connection with the development of the vertebral column. The questions are these :

1. Do all the centra in different classes develop from the skeletogenous layer surrounding the notochordal sheaths as a whole? This question arises since we find variation of shape regarding different forms of centra.

2. As we find variation of thickness and material of centra in the different classes the question is, are the centra of different classes of vertebrata homologous?

3. How are the different types of vertebræ formed, as we find four different types?

4. Variation in thickness in different regions of a single arch or variation in different species is observed, and the question is, are the neural arches of different classes of vertebrata homologous?

5. Why have the Teleostean fishes alone got neural arches made up of membrane bone, and why are they situated either at the anterior or at the posterior extremity of each centrum, and why does the rest of the centrum remain without the neural arch?

6. Is there any marked variation of the development of the centrum within the existing genus, or a marked similarity between two species belonging to different sub-classes? If so, then one is inclined to entertain a doubt as to the validity of the present classification.

4. Vishwa Nath, Lahore.

[In the absence of the author the paper was read by Dr. Misra of the Benares Hindu University.]

The place of cytology in the study of the living animal.

In cytology, or the study of the cell, lies the key to the solution of all biological phenomena, for all organisms are made up of cells. Whatever biological phenomenon we may wish to study—it may be structure, function, development or heredity—we are invariably driven to the study of the cell, the unit mass of protoplasm, which forms the physical basis of life.

It is impossible to exaggerate the importance of the study of the living cell. Curiously enough, after the introduction of the compound microscope in 1590, cells were studied in the living state by the earliest observers. But unfortunately, with the development of cytological technique towards the close of the nineteenth century, the centre of interest was shifted from the study of the living cell to that of fixed and stained material.

Fortunately interest in the study of the living cell has been recently revived and valuable results have been obtained through micro-dissection and tissue culture or through the simpler technique of directly studying fresh cells isolated from the body of the organism.

Probably the greatest achievement of cytology is the demonstration that the nucleus of the cell, or more particularly the chromosomes, constitute the physical basis of hereditary transmission. Apart from the most valuable data which have been collected through the study of fixed and stained preparations, witness the recent works of Bêlar, who has studied the whole process of mitosis in the living cell.

With the above most valuable results in hand the geneticists and the students of eugenics are busily pushing forward their experiments with a view to establishing better breeds or races.

On the contrary, the Neo-Lamarchians are laying increasing stress on the importance of environment or habit in the transformation of species; but whatever the *modus operandi* of evolution may be, the chromosomes will continue to be regarded as the vehicle of hereditary transmission.

Beside chromosomes various protoplasmic structures, such as the mitochondria and the Golgi apparatus, have been recently studied in

the living cell, and our knowledge of the structure of the living cell is much fuller today than it was fifteen years ago.

The cytologist will reach the climax of success when he can create life. The bio-chemist, it is true, has isolated from protoplasm various kinds of most complex compounds. But protoplasm is not a mere mixture of these compounds. It is an organized system, the activities of its various constituents being fully co-ordinated. The protoplasmic compounds are represented by particles which vary endlessly in chemical nature, physical consistency, degree of magnitude and physiological activity, and are constantly acting and reacting upon each other. Until we understand the true nature of these reactions life will continue to be an unsolved puzzle, and the manufacture of protoplasm a cherished dream.

5. Dr. A. B. Misra, Benares.

Dr. Misra stressed the importance of Cytogenetic studies and showed that the variations can be expressed by the various assortments of genes in the chromosomes by linking and crossing over of chromosomes.

6. Prof. W. M. Tattersall, Cardiff.

Systematic Zoology is essentially concerned with the classification of animals and it is the business of the systematists to evolve a natural and true classification of the animals he studies. Hitherto such work has been mainly morphological and for certain animals at least, e.g. the deep sea fauna, must of necessity remain so. Workers on the systematics of terrestrial and shallow water forms, however, are realizing more and more the necessity of studying the living animal if the morphological facts which are the basis of their work are to be correctly interpreted and given their true value in the classificatory scheme. Stephenson in his recent monograph on British anemones has even suggested a major classification of the group on characters which can only be observed on living animal, namely, the method of reproduction, and more or less definitely states that it is impossible to identify correctly a preserved anemone.

As a worker on the systematics of Crustacea I would emphasize the value of the study of the living animal whenever possible and particularly in regard to the following points:—

(1) The morphological changes which accompany growth and more especially growth which takes place after sexual maturity has been reached. Many Crustacea become sexually mature before full growth has been attained and many species have been described which have subsequently been found to be merely growth stage of already described forms. The phenomenon of high and low dimorphism is particularly important in this connection;

(2) the changes which accompany the growth of organs and structure which are regarded as fundamental for classificatory purposes, e.g., the genitalia in many groups of crustacea;

(3) the study of the functions of various organs and structures as a guide to the proper interpretation of their morphology, to an accurate assessment of their real value in classification. I would specially mention here the work which has been done on the feeding mechanism of Crustacea, and on the locomotion or Crustacea for a proper interpretation of the internal musculature.

What is said above about crustacea will probably apply in large measure to other groups of animals. Hora's work on the fauna of mountain torrents, Das' work on the respiratory adaptations of fishes, and Wood Jones' observations on the function of the syndactyl digits of marsupial are notable examples of the valuable results to be obtained from observa-

tions on living animals in the true interpretation of morphological characters.

Systematic zoologists are ultimately concerned with the mechanism of evolution and one of their main problems is to elucidate the cause or causes which have led to the formation of the genera, species and varieties which they describe. Specially important is the study of biological races which can be regarded as species in the making. Such races in many cases are morphologically inseparable, but differ in some biological characters, such as the nature of the food, times of reproduction and so on. For a proper understanding and appreciation of these differences observation on living animal are fundamental and it is in such studies that the ultimate solution of the mechanism of evolution must be sought.

7. PROF. L. F. DE BEAUFORT, Holland.

When we consider the history of morphology we see that after Darwin morphology was merely concerned with phylogeny of organs and therefore the study of *homology* stood on the foreground. We have, I think, fairly got to the end in this way of investigation and now another way of looking at morphology has arisen, where the *function* of the organ is put on the foreground, which involves the study of the living animal. Analogies are studied now and I wish to point out the recent work of Boker, who started quite a new kind of comparative anatomy, which he calls *Biological Comparative Anatomy.*

Dr. B. Prashad, Calcutta and others also took part in the discussion.

X. BLOOD GROUPINGS AND RACIAL CLASSIFICATION.

(*Section of Anthropology.*)

The proceedings of the Anthropology section of the Indian Science Congress began on Tuesday, 4th January, 1938 with an address of welcome by the President, Dr. B. S. Guha, to the foreign delegates and to those who had come from other parts of India.

Before the routine work of the section began Mr. K. P. Chattopadhayaya, Calcutta, moved the following resolution:—

That this section records its deep sense of sorrow at the death of Diwan Bahadur Dr. L. K. Ananthakrishna Iyer, M.D. (Breslau), who was for some time the Head of the Department of Anthropology, Calcutta University, and whose contributions to Anthropology had won for him a recognized place among the leading Anthropologists of the world.

The resolution was passed unanimously all standing.

As already arranged the discussion on 'Blood Groupings and Racial Classification' took place at 1-30 P.M.

Blood Groupings and Racial Classification.

The President, Dr. B. S. Guha asked Dr. E. W. E. Macfarlane to open the discussion.

In opening the discussion Dr. Macfarlane referred to the researches of the Hirschfelds who first drew attention to the high percentage of B in Indians and to the descending values of B as one passes westwards from India. Similar proportions in Gypsies, Colonial communities and their relatives in the home country led many Anthropologists to think of blood grouping as a reliable rest of relationship. The speaker also pointed out that Group O was the oldest and original ancestral group. The group A appears to be very old while B appears to be of recent origin. The dis-

tribution of B has led Synder, Gates and others to conclude that the gene is not derived from the joint ancestors of the anthropoids and hominidæ but has arisen in both as parallel mutations.

In India there are distinct coeval races in every district which have been effectively isolated by the prevailing customs of caste endogamy. There are also communities possessing a preponderance of each of the three alleomorphic genes for blood groups. In south-west the low caste peoples have a very high proportion of group O, and the Hill tribes are righ in A. It has along been known that the greatest concentration of group B is in India, but only within the last few years has an attempt been made to get data from each caste and tribe from each locality separately. Those data are urgently needed and must always be appraised in relation to past migration, isolation, inbreeding and other physical characters of the groups.

It is possible that serological data from India may throw light on the origin of the B gene and also upon the mutation rate. The frequency of B is greater among all the Bengali depressed classes, among the Todas and the 'Dravidians' of Chota Nagpur than in any other peoples. The Cochin State is the only region in India where the frequency of B is less than of A. The frequency of B is lower among the mixed population in Assam, Burma and Tibet than in the Ganges valley, and therefore if B arose independently among the Mongolian tribes it has spread west and south from China. In south Bengal the frequency of A differs little in all communities and B therefore seems to have originated as a mutation direct from O (or R). Mutations to B should still be going on in some stocks and we may find communities with high percentages of group O and of B.

Lastly, the speaker stressed the fact that miscegenation is now becoming more common and it is important to get data as quickly as possible. Further the agglutinogens are supposed to have no selective values and it is very difficult to explain how B spread east and west of India through hybridization. The speaker, however, concluded with the remark that blood grouping is an aid to anthropology; it cannot be alone used for solving a relationship but must be taken into consideration with other racial characters.

Frhr. von Eickstedt of the University of Breslau pointed out how in Germany they were mainly concerned with zoological types and opined that blood grouping may determine physiological types and not the zoological types of India.

Prof. Ruggles Gates said that the blood groups are definite units whose method of inheritance is known. This gives then a great advantage over all physical measurements as indices of racial relationships; for such differences are not only quantitative and subject to fluctuations but the manner of their inheritance and for example, the relation of the cephalic or nasal indices to genic differences is at present largely a matter of conjecture.

The use of the blood groups in connection with racial classification and relationship is largely based upon the development of the theory of mutation frequencies, as he has shown in Genetica, Vol. 18, pp. 47–65, 1936. Like other mutations, they must occur repeatedly with certain frequencies which are low but they undergo changes. The evidence indicates that such changes in frequency are more likely to be sudden and marked than gradual. The evidence also supports the view that O was the original condition in mankind from which A and B have been derived by dominant mutations of the order of frequency of perhaps 1 in 100,000. Since parallel mutations are so frequent in other characters, it is not surprising if A and B have developed as parallel mutations in the Hominidæ and the Anthropoideæ.

The speaker stressed the fact that in comparing the blood groups of different races the results need to be interpreted in terms of (1) isolation, (2) migration, (3) racial crossing. He also suggested that future blood

groups tests should be combined with anthropometric and other measurements in the same individual, since they will help in elucidating the history and relationships of races.

Prof. Gates illustrated his lecture with lantern slides citing examples from India, Tibet, North Africa, Arabia and North America.

Prof. H. J. Fleure pointed out that it seemed desirable to him that the blood characters of the individuals should be recorded along with other physical characters of the same individual and he hoped that it was in that, the correlations which were not yet sufficiently demonstrated could be found out.

Prof. Crew mentioned that it was not impossible that blood groups genes might ultimately be used as genetic markers warning us of their association with lethal genes affecting, for example, the secondary sexual ratio and infantile mortality.

Mr. A. Ananthanarayan Ayer said that the value of blood grouping for giving some evidence about parentage in medico-legal work and between two races living close together was unquestioned, but to use figures of blood grouping to interlink zoological races in different parts of the world seemed irrational. According to him it could only be of very secondary importance to other fundamental anthropological data.

In summarizing from the chair Dr. B. S. Guha remarked that blood grouping must not be taken to supplant our views about racial relationships derived from anatomical characters but they should be considered as furnishing valuable data of a supplementary character, specially of the physiological behaviour of different communities but exactly how they are related to other anatomical characters, we are not quite in a position to judge at present.

XI. A PROGRAMME OF ARCHÆOLOGICAL EXCAVATIONS FOR INDIA.

(Section of Anthropology.)

Discussion on 'A programme of Archæological excavation for India' took place on Friday, the 7th January, 1938 at 2 P.M. with Dr. B. S. Guha in the chair.

In opening the discussion Rao Bahadur K. N. Dikshit said how Archæology in earlier days, i.e., about 75 years ago was mainly confined to excavations here and there without any definite purpose and that it was reserved for Sir John Marshall to give it a systematic turn with a definite purpose. Referring to the epoch-making discovery of Mohenjodaro which opened a new chapter in the history of India Rao Bahadur lamented how for want of sufficient funds from the Government for the last six years, nothing could be done except the preservation of the things already excavated. Citing a long list of the pre-historic sites still awaiting the spade on the archæologists, he urged the systematic excavations of the two sites of Harappa and Mohenjodaro, as they were likely to supply many of the missing links in the cultural sequences of India. As regards the other pre-historic remains the speaker mentioned the Asura sites of Chota Nagpur, which are full of copper ores; the megalithic site in Burdwan, Bengal; the numerous (about 200 in number) sites in Peshawar, the birth place of the Grammarian Panini; the paleolithic sites in Central Provinces and other sites in Bombay Presidency, Maharatta country and Madras. Rao Bahadur concluded by saying that many things were being ruined surreptitiously and it was high time that systematic excavations should begin at once. He thanked the Government that at present it had placed

a comparatively bigger sum for archæological investigations and that he hoped that work would begin very soon.

Mr. N. G. Majumdar who followed, impressed on the necessity of a complete survey of Sind and the contiguous state of Las Bela in Baluchistan.

Rai Bahadur R. P. Chanda pointed out that ancient river beds, such as Saraswati, Sravasti and the river beds of Arabia might reveal many important discoveries.

Mr. K. P. Chattopadhyaya said that the Archæological Department should pay more stress on Pre-historic Archæology and not allow outsiders to exploit the valuable treasures in India and urged that Government should take in Indian scholars trained both in Anthropological and Archæological works.

Dr. M. H. Krishna also referred to the sites in Mysore and pointed out the similarity of Mysore discoveries with those of Maski in Hyderabad.

Prof. Peake pointed out that it was time that we should depend on the spades for truth rather than build theories on tradition and linguistic studies. According to him Indus civilization connects Indian prehistory with neighbouring regions and he urged on the utility of trial excavations in numerous sites with the resources at hand. He also pointed out the necessity of arousing the interest of the rich people and said that trained experts from Europe could be sent to conduct the works of excavations if necessary.

Prof. Fleure thought that excavations of the megalithic sites was very important specially in India where there were still people connected with megalithic culture. He was of the opinion that this might throw light on the pre-Aryan civilizations of India.

Prof. Thomas was of opinion that India with her numerous prehistoric remains should be the centre of an Archæological Institution to which students should flock for training on the spot.

In concluding the discussion the President pointed out how originally Archæology in India was concerned only as a department of history and confined itself mainly to the preservation of ancient monuments and the decipherment of Sanskritic and other written inscriptions. Prehistoric Archæology in the sense in which, it is understood in Western countries was not studied in India. With the discovery of Mohenjodaro its importance has recently been somewhat realized, but this realization is still very partial. For the proper study of Archæology and a scientific reconstruction of the unrecorded history of India it is essential that the Archæological Survey should be reconstituted into a department of Explorations and a department of the preservation of ancient monuments. In the former only people with Western training with experience of excavations in Europe and the Near East should be recruited to excavate and study the innumerable prehistoric sites in this country. With the materials thus recovered it would be possible to build up a correct account of the past history of this country.

XII. THE IMPORTANCE OF ANTHROPOLOGICAL INVESTIGATIONS FOR INDIA.

(Section of Anthropology.)

Discussion on the importance of 'Anthropological investigations for India' took place on Wednesday, 5th January, 1938 at 2 p.m. under the Presidency of Dr. B. S. Guha.

In opening the discussion on 'The importance of Anthropological investigations for India' Rai Bahadur S. C. Roy of Ranchi pointed out that anthropological investigations should no longer be considered as a pleasant diversion. It is time that proper attention be paid to this direction especially in India when her administrative systems is undergoing a change calling for a definite well-considered scheme for the promotion of economic, educational and social interests of her aboriginal population. The different universities of India do not seem to be very alive to the importance of the study of anthropology. It is only in the Calcutta University that Anthropology has been accepted as a subject for post-graduate studies and the universities of Mysore, Lucknow and Bombay have introduced it partially in the post-graduate studies in recent years.

Uptill the present, neither the Central nor the Provincial Governments appear to have paid any particular attention to this matter or at any rate to have formulated any definite policy regarding it. In Europe, Anthropology is a compulsory subject for the Civil Service Examinations specially for those who are competing for Colonial service. But in the Indian Civil Service Examination although it was originally an optional subject, it is now omitted from the list of subjects for the examination held in India. Rai Bahadur Roy stressed the fact that many primitive tribes were dying out and a proper and thorough enquiry into their customs, institutions and mentality was urgently required. Administrative, moral and humanitarian points of view demand that Government should grant adequate funds for the study of the backward and excluded and partially excluded areas. Fortunately the Government of Bombay has in the year 1931 made a gesture in this direction. An attempt is being made there to ameliorate the position of the backward and depressed classes by appointing special officers and spending on an average Rs.35,000 a year.

Rai Bahadur Roy showed from two specific instances from Chota Nagpur how the want of a proper knowledge of the institutions of the primitive people in several cases led to misunderstanding in the minds of the Government officials and how a serious riot was avoided by handling the people with tact and wisdom born of a knowledge of their mentality, customs and beliefs. He concluded by showing the importance of Anthropological study in national life; how a proper understanding of the different peoples, primitive and advanced, might supply a bond of unity between the different communities and ultimately in the realization of a common nationhood.

Mr. K. P. Chattopadhyay who spoke next pointed out what an extensive area in India still remained unstudied. He referred among others to the work specially of Rai Bahadur Roy in Chota Nagpur area and of Dr. Hutton in Assam. He thought that a proper understanding of the material culture and economic condition would help the formulation of a proper scheme of national education. He also pressed the need of an extension of the study of Anthropology.

Baron von Eickstedt said that so far as biological anthropology is concerned very little has been done so far in India but in social anthropology a somewhat greater progress has been made.

Mr. A. N. Chatterji thought that the anthropology of the higher castes was as important as that of the primitive tribes. A proper study in his opinion would help us in solving many of the maladjustments of the middle class.

Prof. Fleure pointed out the large amount of anthropological work particularly on the Castes and Tribes done in India. In England there has, in recent years been an attempt to understand Indian condition and after his return Dr. Hutton was given a Professorship in the University of Cambridge in recognition of his work in India. What was needed now

was to approach the Government of India and to lay stress on the importance of anthropological studies for administrative purposes and get it re-introduced as a subject in the Indian Civil Service. He promised to do his best both in England and India on this matter.

PROF. PEAKE also pressed the necessity of the study of the middle and upper classes along with the study of the primitive and lower classes.

In summing up the President said that the necessity of anthropological investigations from both the social and physical points of view was very great in country like India inhabited by so many races of diverse cultures and languages. It is only through the study of anthropology and not by any amount of pious wishes could these divergent and hetrogenous elements be welded into a nation with common national outlook and ideals.

RESOLUTIONS:

In the meeting of the Anthropological Section, 25th Indian Science Congress on the 8th January, 1938 the following resolutions were passed:—

Prof. H. J. Fleure, F.R.S., of the University of Manchester, moved that:—

'This conference is of opinion that in view of the urgent necessity of an intensive study of biological traits and social institutions of primitive as well as of advanced peoples and cultures in India, it is essential that the Universities and Provincial administrations should make adequate provisions for the teaching of and research in Anthropology.'

'That in order to promote such work, the Central Government be requested to give an independent status to Anthropology as a department of research.'

Prof. Baron von Eickstedt of the University of Breslau seconded the resolution.

The resolution was carried unanimously and it was decided to request Dr. B. S. Guha to draft a reasoned statement in support of the resolution which could be forwarded by the Executive Committee to the various authorities concerned.

Prof. F. W. Thomas of the University of Breslau moved the next resolution:—

'That for proper research in Archæology it is necessary to have a Central Institute of Archæology and Anthropology in India on the line of such institutions of Europe and America as problems of prehistoric archæology and Anthropology are largely interdependent and common and should be studied together.'

Mr. N. G. Majumdar seconded the resolution and was passed unanimously.

XIII. IMMUNITY IN PROTOZOAL INFECTIONS.

(Section of Medical Research.)

The discussion was opened by Dr. Krishnan.

CAPT. S. DATTA referred to the existing protozoal diseases of domestic stock of India and surveyed the present position. He emphasized the general observation that Indian livestock can withstand protozoon infections better than European or other stock imported into this country.

Due to this relative immunity of Indian cattle, they have found favour in different British colonies and Dominions. The resuscitation of protozoon parasites like Coccidia, Trypanosoma, and blood parasites like Babesia, Nutallia, etc. following upon diseases of virus and other origin is constantly seen all over India and must be an important aspect of the study of host-parasite relationship. With the recently organized Section of Protozoology at Mukteswar Institute, the study of the larger issues of Protozoal Immunity has been commenced.

Dr. Vishwanath said that the connotation of the term immunity differs according to whether you are talking of virus, bacterial or protozoal infections. Against the viruses an immunity of long duration is usually developed and passive immunization is also effective. Complement fixation can also be demonstrated easily. The immunity against bacterial diseases in general carries a shorter duration, passive immunization is of not the same strength as in virus infections and is capable of being assessed by search for antibodies in a greater variety of ways. Immunity against Protozoal diseases is not only incapable of passive transference and rather difficult of assessment through search for anti-bodies but by virtual absence of active immunity arising through infection. This absence of acquired active immunity may be due to the Protozoa as members of the animal kingdom not representing as strong a foreign protein as bacterial flora or viruses do. Apart from control of insect vectors we must look for prophylaxis and treatment to immunological products for both active and passive immunization. We must also look to chemotherapy for the control and cure of protozoal infections.

Dr. Ghosh said that there was hardly any quantitative leucocytic response in most of the protozoal infections and this is a significant difference between Bacterial and Protozoal infection. It has been found that by artificially inducing leucocytons by 'Gool' (a primitive indigenous method of inducing leucocytosis) undoubtedly the treatment by chemotherapy, particularly in cases of Kala azar, can be greatly modified.

Another aspect of protozoal infection is that in cases of amoebic infection at least, there is certain amount of loss of power of producing anti-bodies against bacterial infection in the host. This was observed in several cases of chronic Staphylococcal Eczema which could not be cured either by vaccine or by chemotherapy. Amoeba having been detected in the stools, a course of emetine with vaccine cured all those cases of Eczema.

Dr. Seal said that he would like to know whether the so-called protozoal immunity is a resistance to super-infection or a real immunity and whether this resistance or immunity is more manifest in malaria or in Kala azar. It is found that after repeated attacks of Malaria up till the age of 12 properly treated or not, a certain amount of immunity is acquired but still the person may remain susceptible to it whereas a person once cured of Kala azar rarely gets a second attack except in a very limited percentage of cases; cases, completely or incompletely treated, remain highly refractory and suffer from a condition called Dermal leishmanoid or Dermal leishmaniasis first noted by Sir U. N. Brahmachari.

Dr. Poulton stated that after the treatment of G.P.I. by Malaria, it was in England quite easy to stop the infection with a single dose of quinine. In India, he was informed that it is difficult to stop attacks. The Englishman in India is even more susceptible than the Indian. Is it a question of climate? It would be worth comparing hill stations with the plains, etc.

Dr. Ganguli said that he had found response to treatment by quinine and atebrine varied in different persons, a few reacting very quickly and others taking a much longer time, but it had been found that when once the blood had been sterilized with atebrine as confirmed by Bass culture,

the patient did not usually get a relapse. The experiments of Short and others show that even if the blood is sterilized by acridine or atebrine, relapses would immediately occur in a week or two. The effect of the drug has also been found to vary according to the constitution of the person, climate and altitude.

Regarding immunity response in Leishmaniasis, Brahmachari was the first to discover that the Euglobulin factor which is closely associated with immunity, was much increased in the blood of persons suffering from Kala azar. This discovery was not carried far regarding its value for immunity but was utilized as a test for the diagnosis of Kala azar, the chemotherapeutic measures with pentavalent antimony compounds being found to be more efficacious in reducing the incidence of the disease.

In amoebiasis too, it is found that although the symptoms could be quickly controlled by a few injections of emetine and some arsenical compounds, the ultimate eradication of the disease rests on the immunity of the person.

Dr. Das Gupta said that as a result of investigations carried out with regard to the development of immunity in plasmodial infections, the conclusions arrived at by the speaker were as follows:—

Tolerance to reinfection with the same strain of P. Knowlesi in rhesus monkeys may be developed by repeated inoculations of the parasite combined with inadequate treatment. It (tolerance) depends upon the existence of scanty parasites in the body of the monkey ; when the infection is entirely got rid of the animal becomes quite as susceptible as an untreated subject.

From analogy it is not unreasonable to suppose that in the case of human plasmodial infections acquirement of protection against further infection is associated with the presence of the parasite in the body of the individual. And when the infection dies out tolerance to reinfection also disappears, thus showing the temporary protection acquired is far from being true immunity.

Dr. Chatterjee raised the question of the relation between protozoal infection and its antagonism to various other infections. There is the wellknown immunity of Malaria and certain forms of nerve-syphilis. Whether a similar relation exists between Malaria and Plague which is conspicuous by its absence in Bengal and which is prevalent in other parts of India in cold and dry months of the year when the mosquitoes get the least chance to grow.

The speaker also referred to a very neglected subject, that is, the role of red cells in the production of immunity especially in Malaria.

He also raised the question of the source of globulins that are increased in Kala azar and other conditions.

Dr. Dutta observed that :

1. A point has been raised that malaria can be easily treated in England and not in India. In veterinary practice a similar condition is found at the Imperial Veterinary Research Institute, i.e. Babesiasis in cattle can easily be treated in the plains by means of Trypan blue whereas at Mukteswar the same infection does not respond to Trypan blue and other Chemotherapeutic agents have to be resorted to. This drug-fastness may probably be one of the factors in the case of Malaria in India.

2. In Veterinary Practice Protozoa do not appear to give rise to the production of anti-bodies in the animal system to an extent which would enable the use of serum for prophylactic purposes with so great a success as one finds in bacterial and virus diseases, though enough anti-bodies do develop which can be easily detected by means of serological tests. The latter fact is made use of in the diagnosis of various protozoon diseases especially Dourine in equines. Experiments have been carried out at

Mukteswar to prepare an anti-serum against Bovine Theilericasis but the results were not very encouraging as to put this product on the list of saleable biological products at Mukteswar.

3. In equine trypanosomiasis the use of Bayer 205 alone or in combination with Tartar Emetic overcomes the infection on account of the chemical action of the drug on the parasite but again the dead parasites act as antigen and produce active immunity.

4. Acidophilus cultures (long life bacillus) are made use of in avian coccidiosis. It lowers the pH of the intestinal tract and the increased acidity keeps the coccidia under check.

5. In Babesiasis in cattle there is age resistance (resistant in young age) and in infected places the young cattle get the infection and overcome it and remain resistant for the rest of their lives. In this case there is a 'Carrier immunity'.

XIV. NUTRITIONAL DISEASES IN INDIA.

(Section of Medical Research, in co-operation with the Society of Biological Chemists, India.)

PROF. H. ELLIS C. WILSON, Calcutta, opened the discussion.

DR. PROBADH CH. DAS said that there are some manifestations during pregnancy such as stomatitis, gingivitis, ptyalism, pruritus, herpes zoster and cramps in legs, which were formerly classified as due to toxæmia of pregnancy have now been definitely proved to be due to deficiency of certain food products which are necessary for the maintenance of good health. He would like to ask Dr. Wilson if he has any experience about these diseases in India.

DR. HARDIKAR asked wherefrom the vegetarians get their different food factors, the deficiency of which gives rise to deficiency diseases and which it is suggested to make up by adding animal foods to the dietary.

DR. CHATTERJI said that height varies according to castes. Brahmins in general show a greater height than others and Moslems a shorter height. Sea board districts of Bengal show a shorter height and the northern districts a medium height. The districts with laterite soil show a shorter height. The average height is greater in Eastern Bengal than in Western Bengal.

DR. SEAL said that the point which he liked to stress is that apart from the clearly defined deficiency diseases there are, in India, many maladies which though not regarded as of malnutritional origin, should be considered to be due to a suboptional condition of nutrition. This subclinical state of deficiency is the primary cause of general ill-health and lowering of resistance of the various races and nationalities represented in India and is indirectly responsible for the most severe ravages of the country by variety of diseases such as malaria, kala azar, tuberculosis, leprosy, cholera, gastro-intestinal disorders, anæmias, diabetes, dysenteries, etc. The possible relationship of tuberculosis, leprosy, epidemic dropsy, respiratory diseases, and gastro-intestinal disorders, e.g. diarrhœa, dysentery, cholera, peptic ulcers, to dietetic deficiency may be very well represented. It may also be suggested that the incidence of other general diseases such as Malaria, Kala azar, etc. is to a certain extent dependent upon the nutritive factor as well. The solution of the problem of prevention of diseases in India is therefore one of improvement of conditions of living as of food supply of the people by improvement in the methods of

agriculture, animal husbandry and industry and lastly by restraint on reproduction.

DR. CHARUBRATA ROY said that a type of cases are seen which seem to be due to deficiency of vitamines. These cases come with jaundice, night blindness and marked pathological condition of cornea and the vision is much impaired.

On examination, the blood picture is that of anæmia with about 3 million R.B.C. and 45 to 50% of Hæmoglobin (6·3 to 7 gms. of Hb) Van den Bergh's reaction is positive both direct and indirect but the bilirubin content is not very high—3 or 4 units only. The R.B.C. in this case instead of showing more fragility than normal as one would expect in cases of jaundice were less fragile than normal (Hæmolysis taking place with 0·16% Nacl).

Administration of Cod Liver Oil did remarkable good to these cases. In course of 15 days, the whole picture changed and they got cured, in a very short time.

DR. J. N. MAITRA observed that a villager after suffering from night blindness for over 2 months (after a cure of Kala azar and Malaria) was put on an improved diet of milk and fish for 10 days and he left Calcutta cured.

XV. THE PRACTICAL POSSIBILITY OF BREEDING IMMUNE STRAINS OF DOMESTICATED LIVE-STOCK.

(Section of Veterinary Research.)

[No report of the discussions has been received.]

XVI. PHYSIOLOGY OF THE INDIVIDUAL IN HEALTH AND DISEASE.

(Section of Physiology.)

In the absence of the President Col. R. N. Chopra, Prof. Winifred Cullis of London, took the chair.

1. DR. B. MUKERJI (All-India Institute of Hygiene) opened the discussion.

The term Health has never been defined adequately as it is such a variable quantity. It is not merely a *negation of illness* as is generally believed, but also *means something positive.* The full use and control of the mental and physical functions, a vigorous constitution and bodily well-being are the characteristics of a healthy man and these would require the correct and normal functioning of the different parts of which the individual is composed.

Man, in a great many vital functions are actively and quickly responsive to the influences of physical environment. Body growth, speed of development, vigour and energy level, resistance to infection, and many other of his functions are dominated by the stimulating character of the climatic environment.

Climate consists of a large number of components, like temperature, wind, sunshine, seasons, moisture, storms, etc., of which medical science

still knows very little, although it is probably one of the most important factors in the life of man. Climate has a direct effect upon health and an indirect effect through food, incidence of disease and mode of life. Huntington in his book on 'Civilization and climate' endeavours to show that all the progressive races, which are distinguished by high energy level, civilization, and achievement in practical, scientific and intellectual spheres, live in particular types of climates which are characterized by their variability and their comparatively low mean temperatures. He contends that the old civilizations actually existed in such climates and that the decay of these civilizations was due to a gradual change of the climate to an equable or sub-tropical nature. In olden times the optimum climate was almost certainly further south than it is at the present time, and the view that Arabia, Syria and Mesopotamia once possessed a climate differing considerably from that of today is rapidly becoming accepted. Although the mean temperature in those countries may have altered little, there is hardly any doubt that they had abundant rain two thousand years ago, as, though now desert, they were then richly fertile and able to support many millions of people. According to him, civilization and progress unquestionably influence health, and health has an effect on energy, but neither of them can conquer climate and it seems certain that climate, therefore, must influence civilization, health, energy, etc.

Huntington's claims are not entirely fanciful and theoretical. Evidences of a biological nature are now accumulating, in increasing proportions, which point unmistakeably to the deductions made by Huntington on geographical and other grounds. Amongst the most fundamental of the indices of individual or mass welfare are those of growth and development. Incidental disease usually acts to depress these indices, but probably of greater importance is the increased susceptibility to disease that come with suppression of growth through such factors as deficient diet, lack of sunlight or debilitating climate. It had been recorded from extensive statistical studies that the growth in both height and weight of children is rapid in northern U.S.A. and North Central Europe, and drops sharply in the case of children in Italy, still more so in the Philippines and in Japan. These differences would at once raise the question for many people as to the racial differences in body-build, but they also raise the question whether such racial differences may not be basically those of diet or climate acting through the centuries. It is a well-known fact that Japanese, Philippinos, or Italians brought up in the climate of the northern United States showed a stature and body weight distinctly superior to those of the people remaining in their homeland. This improvement has been attributed by one group of workers to better economic status, and more ample diet. But apparently this explanation cannot be considered completely adequate. Studies on the growth of laboratory animals under well controlled conditions have shown clearly the climatic dominance over growth even when the diet was entirely adequate and held constant for all experimental groups. At least a presumptive basis was thus afforded for the belief that the slower body development in Indian children might also be due to the depressing moist heat of this conntry, and not primarily to a dietary deficiency.

Then again, there are definite evidence of physical deterioration in the tropical climate. From extensive statistical analysis of life expectancy, it has been shown that the majority of the tropical inhabitants reach old age when Europeans have barely attained middle age. In England, presbyopia due to progressive weakening of internal eye muscles becomes manifest at the age of forty-five and even later, whereas among the tropical races it comes on at about the age of thirty-five and even earlier. The same is true of senile cataract (a degenerative change in the lens of the eye causing opacity), which occurs more frequently and develops earlier in those people who inhabit hot countries. In the United States, factory statistics prove that in the south the power of sustained energy is lower than in the superior climate of the north; and also that the power of mental

and physical energy of those immigrants, and their descendants, who have come from an inferior climate, although improved, remains lower than that of peoples who have immigrated from a superior climate.

These evidences, taken together with the observations made by the learned president in his 'Presidential Address', leave little room for doubt that climate exerts a definite effect on the physical and physiological mechanisms of the body. The tropical individual is exposed to climatic changes which are different from those affecting the inhabitants of the temperate climes and hence the physiology of these two groups of individuals may be different. This viewpoint is important in the treatment of disease. Unless the normals are known for tropical people, the interpretation of many biophysical and biochemical alterations in the body fluids in different diseases will be subject to serious fallacy.

2. Dr. B. B. Dikshit (Haffkine Institute) said that there is reason to believe that there is a certain amount of change in the physiology of the individual in disease. This is illustrated by the fact that the physiological action of some drugs like the antipyretics is different in health and disease. His own observations on the choline esterase content of blood in toxæmia have shown that in toxæmia such as induced by plague infection (*B. pestis*), there is a marked reduction in choline esterase values of animals. These values come back to normal after natural or artificial recovery. As choline esterase is concerned in regulating the action of acetyl choline and as acetyl choline is so very important in regulating the physiological activities of the body, the reduction in choline esterase values of blood in disease is significant.

3. Mr. N. K. Iyengar (Institute of Hygiene) suggested that a study of the *in vitro* action of choline esterase on suspensions of *B. pestis* or in similar types of toxæmia should be done with a view to ascertain how this process of detoxification takes place through choline esterase. This will throw light on Dr. Dikshit's observations on the diminution of cholene esterase content of blood in toxæmic processes.

4. Prof. W. Straub (Munich) remarked that the range of physiological activity is within wide limits and the body can gradually adjust itself to changed conditions which in ordinary circumstances would prove fatal. Those who are accustomed to taking beetle nut in India, habitually take an amount of arecoline which will prove highly injurious or even fatal to those who are not at all accustomed to it. He further remarked that climate must have an important part to play in both physiological and pathological conditions. The Englishman, for example, always take tea as their beverage and the Arabs, Coffee. This has been usually explained on the easy availability of each beverage in the respective places. While working on the pharmacology of these drugs particularly with reference to their metabolism and excretion, he found that coffee is easily broken down in the system and is rapidly excreted, whereas tea stays for a longer period in the system and takes a longer time to be excreted. The habit of the Englishman in sticking to tea instead of adopting coffee, is probably due to this knowledge instinctively gained. The cold climate in England possibly demands a longer stimulation which naturally is not needed in Arabia.

5. Dr. Mir Mansur Ali (Institute of Hygiene) remarked that it will be of great advantage if this aspect of physiology was given more attention to.

6. Dr. B. B. Sarkar (Calcutta University) pointed out that man is dependent for his very existence on his power of adaptation to the environmental changes, not only external to his body but also internal, i.e., the environment of his body cells. His two sets of regulators—the nervous system with the receptors and the endocrine system help him to adjust himself to new conditions. In disease the body tries to adjust itself to the

changed conditions, to which the system of the individual has been exposed, so as to carry on the physiological process. Pathology can thus be described as abnormal physiology or the physiology of disease.

7. DR. E. P. POULTON (London) reminded the audience that the physiological standards vary in different conditions. The average weight for height standard which is taken as normal in the case of persons above fifty, even by the Insurance Companies is not correct. It has been found by statistical analysis that persons whose weight for height values at this age are below this average figure, live longer than person whose values confirm to this average or is higher.

8. DR. K. VENKATACHALAM (Madras) remarked that the definition of a physiological constant is difficult to give, as the human system is constantly adjusting itself to environmental changes. He gave evidences of various diseases where a distinct predilection to climate was noticed. Angina pectoris, hypertension, diabetes, nephritis, leprosy, etc. have been definitely shown to be predicated by climatic changes. Certain diseases occur more frequently in a cold climate and during the winter while other diseases are definitely more prominent during the summer and hot climates.

XVII. DIET AND ADAPTATION TO CLIMATE.

(Section of Physiology, in co-operation with the Society of Biological Chemists, India.)

1. PROF. H. ELLIS C. WILSON, Calcutta, opened the discussion.

The question of diet and adaptation might be looked at in two ways. Did a man adapt his diet to the environment, or in how far was food in any particular region of the world suited to man's needs?

Buckle in his 'History of Civilization' written nearly 100 years ago pointed out that Nature provided fat which had a high energy value in the Polar regions and starchy foods at the Equator. This viewpoint appears now to be borne out by recent experimental data. Foods rich in starchy material tended to keep the body more saturated with a reserve of mobile fluid which was evaporated from the skin and helped to keep the body cool in a tropical climate. The two cereals, rice and wheat or atta, offered a somewhat similar picture. Wheat was consumed in the temperate and sub-tropical regions and rice in the tropics. Investigations in the human subject had shown that rice, in contrast to 'atta' (wheat flour), provided the body with a greater reserve of mobile fluid both for evaporation from the skin and excretion by the kidney. Further, rice contained somewhat less minerals than 'atta'. These two properties probably rendered those who consumed rice less liable to deposit stone in the bladder than those who ate wheat. It was well known that this condition was commoner in the Punjab where 'atta' was the staple cereal, than in Bengal.

These few observations would tend to rescue rice and its unpleasant associations with beriberi and possibly epidemic dropsy from the *harijan* (untouchable) position it tended to hold in cereal society.

2. DR. B. C. GUHA (University College of Science) remarked that in determining the quantity of protein that should be consumed in the tropics, the specific dynamic action of protein should be considered. In a tropical country it would seem, from a *priori* consideration, that the quantity of protein required for optimum nutrition may be less than that required in temperate climates. It should be emphasized, however, that the consumption of protein of higher biological value should be encouraged.

As regards iron, it has been found that the daily intake of ionisable iron per head by the students residing in the college hostels in Calcutta varies between 4 mg. to 7 mg. which seems to be slightly lower than the optimum quantity which has been recommended. As regards vitamin C, considering the lower basal metabolism in India, it is probable that a smaller quantity of vitamin C, may be necessary in India than in colder climates. It is difficult to give any authoritative opinion on these findings at present. When nutritional standards for India are determined many such problems will be clarified.

3. Prof. N. M. Basu (Presidency College) remarked that the quantity of protein that is taken in some parts of India is indeed low, for Beharees and people of U.P. are mostly vagetarians. But the curious fact is that labourers in Calcutta, who possess very good physique and are indefatigable workers, are mostly people recruited from these provinces. How are we to explain this? Is it then possible that essential amino-acids are formed in their bodies. This being the case, the biological value of proteins should not be given so much stress, as is done. Berg also raised similar questions in Germany. He has shown that the amount of protein taken may be reduced to a considerable extent, if the acid-base balance in the food is maintained and if the person is accustomed to a low protein diet.

4. Dr. H. N. Chatterjee (Carmichæl Medical College) remarked that hæmotological findings carried out by himself showed definite abnormal values in females, specially in mothers. The number of anæmia cases were remarkably more numerous in females than in males. Possibly this might be due to their food habits as it is the custom of the Hindu housewife to take her meals after the other members of her household have fed, and it is not unlikely that the women folks actually get less nutritious material from the already poor daily diet of an average Bengalee household.

5. Dr. S. N. Roy (Carmichæl Medical College) remarked that an increased carbohydrate uptake will induce a greater output of water both by the kidneys as well as by the skin, resulting in the greater washing out of the body tissues and depletion of soluble mineral salts. As Indian dietaries are deficient in many mineral salts specially calcium, this greater output of water by the body may be harmful. This lower intake and greater outflowing of calcium from the system may explain the shorter stature of rice eating inhabitants of India.

6. Dr. J. G. Parekh (Bombay) remarked that it is generally agreed that the Basal metabolic rate is lower of the Indians as compared with the Western Standard. He has further observed that vegetarians have a lower Basal metabolic rate on an average about 3% lower than those who take meat diet. The majority of Indians are vegetarians and this vegetarianism is perhaps physiological and an adaptive mechanism to the demands of a tropical climate.

7. Dr. B. B. Sarkar pointed out that in a particular locality, inhabitants apparently have, from long experience extending over generations, evolved a dietary suitable for the particular conditions of temperature, climate, humidity, available food materials, etc. of the country. This dietary history of the people has an important bearing on their nutrition but unfortunately this aspect of the question has not, as yet, received the proper attention of physiologists. Classes of people accustomed to take high carbohydrate diet for generations have a different nutritional history from the classes of people who have been living on a high protein diet. The dietary habits of the people should be taken into consideration when devising their diets.

8. Dr. B. Mukerji remarked that Dr. Wilson has referred to the superior water-binding power of the carbohydrates and the role it plays in water metabolism and water exchange from the body. In this con-

nection he would like to enquire whether there was any difference between the water-retaining capacity of 'rice' and 'atta'. Rice is the staple diet in Central and South India whereas 'atta' is the important food in the Northern parts. Whether this habit of rice eating in certain parts of India and 'atta' eating in other parts have anything to do with heat regulation phenomena? The humid heat of Central and Southern India would exert a severer strain on the phenomena of water exchange.

9. Dr. B. Narayana (Patna) remarked that heredity may play an important part in the health of an individual living on a particular diet. There are families who have been vegetarians for generations and who have been living on very low protein diet and that too of low biological value, are keeping good health and living to a good old age. It is necessary that statistical observations be made on the subject with a view to finding out if heredity at all is responsible for adaptation to a particular diet.

10. Dr. Yodh (Bombay) pointed out the importance of the economic factor in the study of diet.

11. Dr. D. Mitter (Institute of Hygiene) remarked that for supplying biologically complete proteins to the poorer masses in India, it would appear that one should aim at supplying more varied proteins through vegetable sources supplemented with a little milk or egg, because it is found that absorption of protein takes place better at basal levels.

12. Dr. U. Basu (Calcutta) said that to maintain the Normal Hæmoglobin level in infants they should be given 'Palo' (*curcuma zeodoria*) as this cereal is rich in iron.

13. Dr. Mir Mansur Ali remarked that in diet and nutrition apart from environmental factor, the psychological factor cannot be ignored. It has been observed that students living under the same environmental conditions and taking the same food, have different nutrition standards in health. This may be due to the suitability of a particular type of food to the fancy of a particular group of students. This 'liking' factor probably operates through the digestive system and selective absorption.

14. Dr. Neil Edwards (Institute of Hygiene) suggested that the low figures for Hæmoglobin which has been observed by some workers in Indian women may be due to the fact that those cases were not in good health and that pregnancy and lactation may have unfavourably affected the findings. In a small series of hæmatological studies carried out on healthy young women (buoyantly healthy) in Calcutta, the findings compared favourably with the standards mentioned in the literature for British women. There does not seem therefore to have a great difference between the blood picture of women in the two countries. Before pronouncing any opinion on minute differences, the factors due to disease, etc. should be completely eliminated.

XVIII. CONTRIBUTIONS OF ABNORMAL PSYCHOLOGY TO NORMAL PSYCHOLOGY.

(*Section of Psychology.*)

Dr. G. Bose presided.

1. Dr. S. C. Mitra, Calcutta.

Various factors contributed to the rise of modern psychology towards the end of the last century. Since the establishment by Wundt of the

first Laboratory in the University of Leipzig, psychology has been making steady progress. Of all the events in the world of thought that have influenced the course of the psychological science the rise and progress of abnormal psychology has been the most outstanding one and the most effective. Psycho-analysis is the most comprehensive of all the prevailing schools of abnormal psychology.

Behaviourism and psychology have entirely different universes of discourse. Therefore the former is constitutionally unable to take the place of the latter. Behaviourism cannot properly be considered as a mental science. There is an absence of dynamic principle in 'existentialism'. The principles of 'existential' school lead to pure abstractions which bear no contact with the realities of life. The methods of mental measurement are sometimes able to render practical help in certain concrete situations of life, but they are no guide to the understanding of the intricate problems of mind. The principles of Gestalt psychology give a good phenomenological description of mental states and functions. But personal subjective experiences are characterized by a peculiar feeling of intimacy and therefore we cannot remain satisfied with merely phenomenological descriptions.

Psycho-analysis gives us not only a better and more thorough explanation of each of the psychological phenomena traditionally treated in the text-books, but also of other normal psychical experiences usually neglected in them. In addition it supplies us with a method by following which we are enabled to reach the innermost core of a person's psyche. The objection that the conclusions of psycho-analysis are based on observation of abnormal mind and therefore are inapplicable to the processes of normal minds, does not hold. There is a continuous gradation between accepted normality and proved abnormality and the only criterion of normality that we can adopt is what Bose has laid down, viz., harmony with the social standard of the place and with the time. It is legitimate to assume that the principles governing the inner mechanism of all minds are the same every where and whether the manifestations of a particular one should be dubbed normal or abnormal would depend purely on external considerations, viz., the social standard.

Psycho-analysis has widely extended the borders of psychology by revealing regions of the mind hitherto not traversed or not thought fit to be traced. Dreams, misplacing of objects, forgetting of names and hundred other similar occurrences, are normal psychological phenomena, but in pre-analytical days they were not given their dues in the text-books. Psycho-analysis has given precise definitions of the terms unconscious, subconscious, etc. It has demonstrated the immense influence that the Unconscious exerts on all psychological experiences. It has made significant contribution in the sphere of memory. One of its conclusions regarding the influence of the Unconscious has been experimentally and verified by Maiti in the Laboratory of Calcutta. Bose's theory of action-attitude gives a better explanation of illusions. Another great achievement of psycho-analysis lies in the domain of feelings and emotions. The ambivalence of feelings, the ways of transformations of emotions, the complexes, and conflicts and their influence on the development of personality, the rôle of emotions in the early life of the child are but some of the most important contributions that have been made by psycho-analysis to psychology. In spite of the protestations of many the discovery of the sex instinct and of sex emotions in children by which is meant not only the presence of these in the children, but their gradual development through the various stages, beginning from the polymorphous perverse stage in infants to the normal heterosexual stage in the adults is one of the highest achievements in the study of man's mind and is bound to be recognized sooner or later as one of the greatest discoveries of the age. This discovery has entirely changed the outlook of the teachers and educators all the world over regarding the ideas and methods of their noble mission.

Psycho-analytical studies of affections and emotions have helped to elucidate more clearly and systematically our appreciation and creation of all fine arts and literature.

Not only actions of particular individuals but those of collective groups also are more fully expounded now on the psycho-analytical principles. While anthropology and sociology, history and even politics are imbued now with the spirit of the new investigations, the studies of customs and traditions, morality and religion have been given a fresh impetus and a new orientation to the advantage of all concerned. To take only two illustrations: Freud's explanations of the influence of the mob and the group and his theory of the development of the super-ego, popularly called conscience, remain unsurpassed as pieces of deep psychological analysis and close systematic thinking.

Only general outlines of the contributions of psycho-analysis to normal psychology have been given in this paper. The virtues of perfection and completeness for psycho-analysis are not claimed. But it can safely be said that psycho-analysis has not only enriched both in quality and in quantity every topic of normal psychology but enlivened the whole science itself so that the latter pulsates now with the new vigour and boldly attacks the problems of life that only the other day it made it a point to evade. And for this metamorphosis of psychology credit must needs go to Freud's discovery of the Unconscious, which event has consequently been very justly listed with the Copernican discovery and the Darwinian theory as the third landmark in the way of progress of the sciences.

2. Lt.-Col. Owen Berkeley-Hill, Ranchi.

The criterion of normality referred to in the above paper is not accepted. The term 'normal' has two meanings.—First it may mean 'the most usual' or the 'average'. In other words 'normal' in this sense has a 'statistical' connotation. On the other hand 'normal' may be made to mean the 'healthy' as opposed to the 'diseased', in which case it has an 'evaluative' connotation. Most of us tend to confuse these two meanings, because our ideas of what is 'good' or 'healthy' are largely determined by what is most prevalent although not always consistently because there are qualities, e.g. abilities which we admire when present in an unusual degree. We may ask ourselves therefore how far we should allow our view as to what constitutes 'normal' or 'abnormal' psychology to be influenced by what, on the one hand, is evaluatively normal and by what, on the other hand, is statistically normal. This difficulty which is not a small one, will be got over as soon as we talk of psychology and make no distinction between the normal and abnormal psychology. Under such conditions the title of the symposium would have been 'The Debt of Psychology to Psychotherapy'.

3. Mr. H. D. Bhattacharyya, Dacca.

At bottom the question of normality is intimately bound up with the question of social existence. No wonder that the study of the social mind should acquire increasing importance with the development of the study of abnormal mind. Academic psychology ignored both the depth and extent of the human mind. The concept of epigenesis or creative synthesis tried to supply the element of unity and organization, but did not succeed.

Functionalism also did not improve matters. In one word, academic psychology suffered more or less from the tyranny of generalization and abstraction and it neglected the special constituents of individual minds and their historical growth in reaction to definite environmental conditions.

The rise of individual psychology is coeval with the development of abnormal psychology. The personal individual is not exactly a representative of his class in the same sense in which one inorganic substance can

take the place of another belonging to the same class. Each case therefore must be studied in his historical growth and must form the subject-matter of individual attention, analysis and treatment. To ignore the historical setting of a given conduct is to obliterate the distinction between the inorganic and organic and to deny as Bergson effectively and eloquently preaches, the reality of time.

The discovery of the individual has been accompanied by the finding that without reference to the social milieu the growth of individuality cannot be understood at all. Abnormal psychology has been mainly instrumental in drawing attention to the great part played by society in moulding the development of the individual minds. To the lasting credit of abnormal psychology be it said that it has shown most effectively the result of conflict between personal desires and social requirements. It has been able to demonstrate that unsocial tendencies that do not succeed in getting an expression managed to survive in the cavern of the mind and even sally forth on occasions in disguised forms and produce psychopathologies of daily life like forgetfulness of names and things, psychogenic falsities like hallucinations, illusions and dreams, veiled obscenities like smutty jokes, pornographic tales, sensual emblems in art and religion and also unaccountable humours and sudden conversions. It has familiarized us to the facts of dissociations of personality. The successful attempt of psychologists to reintegrate the dissociated strands of personality and to restore the normal reaction to society must be accepted as the virtual verification of their hypothesis regarding the mind and its workings. Even with the best of intentions a man cannot fathom the depths of his own soul by mere introspection, for much of what passes for rational thinking is at bottom rationalization and what apparently passes for a true motive of action may be only a cloak for some deeper lying intention of which the conscious mind is not aware at all. So the definition of man as a rational animal should not be understood in the sense that man is rational at all times or that he knows the reasons of his conscious states in all cases or, in fact, in any case. He is a creature of impulses and desires and his normal and morbid reactions are all prompted by the inner urges—many of libidinous character and all designed to fulfil this or that wish of a conscious or unconscious kind. A presumption is raised that there is such a thing as the rational unconscious and the existence of typical symbols in dreams serves to indicate that some common factor activates thinking in slumber.

Abnormal psychology has established the fact that mind attempts at all times to effect an adjustment to given situations. Compromise is writ large across the face of the mind. To avoid coming into constant conflict with society the individual develops the super-ego and thus sets up a miniature machinary within itself to curb the insistent urges of the antisocial id from below the levels of consciousness. In between the super-ego and the id lies the ego—the life of consciousness and compromise. Abnormal psychology has also made valuable contributions towards an understanding of crowd leadership, religious devotion, social taboo and totem and kindred phenomena of the individual and social mind. The greatest contributions of abnormal psychology are two, viz., that the self is a unity in diversity (mimicking in this respect the relationship of the Absolute and the finite selves) and that identical principles operates in different fields of mental activity, individual and social.

4. Mr. Jamuna Prosad, Patna.

One cannot but agree with the general theme of the leading article, but there is an obvious one-sidedness in the discourse. In it normal psychology is altogether denounced as stale, incompetent, and useless. But it should be pointed out that many valuable facts and principles about psychological topics, e.g. about emotion, were known to normal psychology independently of the finding of the abnormal. There are other

schools of abnormal psychology besides psycho-analysis which have not been even referred to. Jung's word association experiment, Adler's observations on 'Inferiority Complex', the works of Janet and Prince on dissociation have been neglected. Secondly no science should have a craving for popular approval, a craze for 'blazing forth before the admiring gaze of the public'. Even psycho-analysis does not care for the blessings of the man in the street nor for the 'good sense and fine feelings' of the elite. Thirdly while it may be admitted that the traditional existential and academic psychology are a failure, the dynamic and functional schools have undeniably contributed towards our understanding of the human nature in the various aspects. On the other hand the success of psycho-analysis in solving the mysteries of the human nature may very well be doubted. Even in regard to the problem of neurosis it is believed by many psycho-analysts themselves 'that psycho-analysis has no answer as to the fundamental basis of the development of neurosis'. In regard to anxiety as the basis of neurosis Freud has openly admitted in his *New Introductory Lectures on Psycho-analysis* 'that everything here is in a state of flux'.

It is unhesitatingly affirmed in the leading article that the highest achievement of psycho-analysis is the discovery of the infantile sexuality and of the stages of growth from the 'polymorphous perverse' to the normal hetero-sexual stage. General psychology, however, has not accepted the whole story as true, rather it has strongly repudiated the suggestion that the child is nothing but sexuality incarnate. Stern, a recognized authority on the Child Psychology, points out that the belief in the sexuality of infants is a curious instance of 'reversed' projection from the so-called reminiscences of adult neurotics. It is only the psycho-analytical child psychologists, e.g. Anna Freud, Melanie Klein, etc. who are convinced of the sexuality of infants. The grotesque phrase 'polymorphous perverse' is inapplicable to the child and betrays a serious lack of understanding of the child mind. All the evidence regarding infantile sexuality is based on data, rather of the selected type. The so-called reminiscences of the adult neurotics on which the whole theory of the infantile sexuality is based, have in most cases, proved to be mere fantasies and justifications of the patients' special attitude in the psycho-analysts' consulting room.

As regards the contributions of psycho-analysis a division should be made between (1) those which are of real value to general psychology and have been more or less definitely adopted by it, and (2) those which are of doubtful value to it and remain confined to psychoanalytic works as characteristically distinctive of their special creed, marred by exaggeration and even lacking in evidence.

In some important respects psycho-analysis has done a positive disservice to psychology. Its mechanistic conception of mind, and its erroneous genetic principles are instances. Justice has not been done to the developmental impulse which actuates man's life ever since the foundations of its birth are laid, and which is perpetually expressed in his longing to be more than what he finds himself to be. As a result we get a curiously inverted view, viz., the test of the normal lies in the abnormal and that normality is repressed abnormality. But credit must be given to Freud for recognizing recently, this much at least, that the Oedipus Complex has passed away and does not exist in the normals, and greater credit still for his more recent assertion even in regard to the neurotics, that we shall have to abandon the universality of the dictum that the 'Oedipus Complex is the nucleus of the neurosis'.

The unnecessary laziness and even lack of willingness of normal psychology to assimilate many valuable contribution of abnormal psychology are to be admitted. But probably there is some real difficulty in the task of assimilation on account of the new concepts and terms of abnormal psychology, which somehow remain alien to and refuse to fall easily in line with those of normal psychology. Consequently it continues to remain typically the psychology of the conscious, unmindful of the

the risk of remaining distinctly poor for neglecting the unconscious. A constructive suggestion may be made. What we need is a seriously planned out scheme requiring the joint efforts of many to work together in close collaboration in order to evaluate and readopt the contributions, not of psycho-analysis alone, but of all schools of abnormal psychology, so that a new type of general psychology, having a close touch with the concrete problems of real life, may be produced, and we may advance towards a wider, deeper, and truer understanding of human nature.

5. DR. T. PURUSHOTTAM, Waltair.

The importance of the criticism levelled against Freudian and other psycho-analytical schools of psychology, viz., that they err in attempting to give us a picture of normal mind and its operations by attempting a reconstruction of that picture from the data obtained in the field of mental pathology or abnormality, should not be minimized. But it holds valid on the assumption that abnormal psychology adopted method which evolved in the consulting room of the physician. This assumption is untrue. The greatest discovery of Freud's lifetime is in the province of the psychology of the *Dreams*. His insight into the mechanisms of neuroses is but a logical development of his initial insight into the nature of the dream. The principles formulated therein are indispensable to a comprehension of mind as *MIND*. The scope of Freud's discoveries remains general, i.e. not restricted to the field of abnormality or pathology. Froud conceives the psychological individual in the light of strict determinism. Whatever the scientific value of such contributions to our understanding of Mind may be, it is obvious that in their relevancy and scope the ideas belong to normal psychology.

Before Freud, there has been no psychological objectivity worth mentioning. Psychology fails as a science because of lack of such objectivity. Objectivity in psychology is achieved only when the object of psychological study is grasped not as a robot or a vegetable or an instinct-ridden psychophysical organism, but as the living mind—what lives on more than food, what shapes and uses the instruments of its action, and grasps all things and worlds for the sweetnesses thereof.

That the energy of the living mind is libidinal is one observation of Freud that will remain unsurpassed for its acuteness for well over a century to come. We live in times to near the event. It is pardonable if we don't realize the entire scope of that great observation. May be, Freud himself does not realize it. It is an observation of genius. Its confirmation will have to be found along every avenue of approach to truth concerning the living mind, whether it is manifested in the deep sea, or in the birds of the air or in man, individual or collective. Such confirmation is already forthcoming.

The principle of libido takes priority over even vital process, and thus proposes a psychological foundation for, and bestows a psychological character upon, phenomena which we are normally inclined to regard as a-psychic, i.e. biochemical, physiological, evolutionary, vital, etc. It is highly significant that even in sexually differentiated organism, libidinal manifestations precedes in ontogeny (and probably too in phylogeny) the development of sexual apparatuses. Libido is a wider conception than Sex. It is the fundamental attribute of all life as the Joy that breaks into living forms.

The terms 'conflict', 'repression', 'resistance', 'dissociation', 'fixation', 'regression', etc. have thrown light on many biological phenomena and profoundly influenced the scientific thought. Psychology can ill-afford to let sister sciences profit out of its own wealth, itself remaining callous to its vast treasure.

Maranon presents data which force on us the conviction that individual bisexuality is normal feature of individual existence.

The co-ordination of the discoveries of Maranon with the doctrines of the Freudian psychology is a piece of work yet to be accomplished. It is one which devolves upon the psychologists of our own generation.

While general psychology appears to be slow to plumb the depths of the individual 'psyche', sister sciences are marching forward developing the concept and enriching its content. Erich Wittkower addressing the Psychiatric section of the British Medical Association, demands a psychological foundation for scientific pharmacopœia and medicine.

Let it be reiterated that the proper object of psychological study is the psyche and that the facts of abnormal mental life, as well as those of normality, have forced upon us anew the importance of recognizing the reality and pervasiveness of the thinking 'thing', 'res cogitans' of Des Cartes.

'Mano mayah prana sareera nata,
Pratishtitho(a)nne hridayam sannidhaya.'

It is to be wondered whether normal psychology in all its extent and applications can hope to find a more appropriate object for its contemplation.

6. Dr. J. K. Sarkar, Muzaffarpur.

Psycho-analysis has thrown much light upon the intricate problems or the obscurer phenomena of thought, feeling and behaviour. But behaviour is many sided. No single branch of psychology can take charge of the human behaviour in entirety. Behaviourism maintains a thorough going legitimate, scientific attitude. Its studies of conditioned reflexes and glandular secretions are significant but its fallacy lies in taking motor and glandular responses as ultimate. Existentialism is a pure science and as such should be distinguished from psychology as an applied science. Test psychology is also purely scientific and experimental. So also is Gestalt Psychology. According to Collins and Drever a psychology which is not experimental is to-day an anachronism in any department of mental life. While some experimental works have been done in the fields of word association and aberrant behaviour, the difficulties that are met in the application of experimental method to psycho-analysis are very great indeed. In view of the vast benefit that psychology would be likely to derive, if psycho-analysis could be made amenable to experimental technique, the attempt seems emphatically to be worth the making. Detailed analysis of conscious sense perception shows that the unconscious lies at the core of all conscious processes. That *it itself* is the foundation on which normal psychology stands, is the greatest contribution made by abnormal psychology to the former.

7. Mr. H. P. Maiti, Calcutta.

The choice of the subject-matter of the present symposium is very appropriate. It focusses our critical attention to the important problem of the influence of psycho-analysis on psychology. Large number of psychologists in India are still very much 'academic'. The symposium may serve a valuable purpose by drawing their pointed attention to one of the outstanding aspects of modern psychology that appears to have given us a key to many mysteries of human nature. All the views expressed in the leading paper as also the total impression regarding the worthlessness of non-psychoanalytical psychology conveyed by that paper cannot be subscribed to. The metamorphosis of psycho-analysis to psychology is not an accomplished fact and is yet to come. Psycho-analysis is not the most comprehensive of all the prevailing schools of abnormal psychology. Psychiatric school lays claim to valuable contributions in addition to helping the growth of psycho-analysis itself. It has partly stimulated the development of mental tests and specially of personality tests.

All the schools of contemporary psychology, including the psycho-analytical, are partial in outlook. The leader of the symposium writing as a schoolman himself, has failed to give due weight to this fact in his summary criticism of the various schools. The particular aspect from which psycho-analysis studies life is that of the Unconscious. But it cannot or does not deny the value of the conscious aspect ; for, it has not only to begin work of analysis, but also to carry it on, from the plane of consciousness. Psycho-analysis starts from from a sort of normal psychology, e.g. psychology of consciously motivated conduct ; proceeds to an assumption of hypothetical motives in the case of apparently unmotivated behaviour ; gathers support for this assumption from therapeutic success and wide range of applicability of its hypotheses ; and finally comes to revise the normal psychology with which it began. The detailed explanation of the unconscious has added materially to our knowledge of the emotional life of man and the significance of the new knowledge for practical life is immense. But these contributions only supplement the phenomenal descriptions of the psychologists and the physiological findings of investigators like Cannon.

Psycho-analysis represents a partial outlook and approach like the other schools, but it cannot be denied that its significance for the future of psychology as well as of human life is much greater than that of any other contemporary school. It is better to remain eclectic in the present state of our science than to identify oneself with the psychoanalytic school.

As regards the positive contributions of psycho-analysis nothing need be added to what has been said in the leading paper. The discovery of the social implication of our behaviour, overt or implicit, is very significant. The Mental Hygiene Movement, the New education and many other such movements are based on the concept of the unconscious. The hypothesis of the unconscious therefore has a pragmatic superiority in comparison with the neurological one for psychological research.

There is need for contact and co-operation between psycho-analysis and psychology. Reactions of assimilation, specially from the side of normal psychology are already on the way, as will be evident from the text-books and histories of psychology recently published. But there are some difficulties to be overcome. The main difficulty is one of method. A scientist cannot be expected to accept a fact or theory relating to his science without verification for himself. Use of the clinical method in some form in the Laboratory would certainly help the reapproachment work to a great extent. With increase in the number of Normal Analysis it would be possible to have a sufficient number of Laboratory subjects, for a series of Free Association sittings to warrant generalisation about unconscious factors after the experimental ideal of Normal Psychologists.

The idea is current among some that as the clinical method works *en masse* on the personality and not any simple abstracted feature of it, it cannot be a scientific method. But the clinical method of psycho-analysis at least on its exploratory side is comparable in essentials to an accepted laboratory method. The similarity has been pointed out by the writer in a paper to be published shortly, dealing with the reaction time experiment.

The psycho-analytical terms and concepts appear to many to be cumbrous and substantive in import. Psychologists cannot be asked to reconcile themselves easily to believe in the mental substantive after their sustained labour for centuries to throw them out. We shall have in near future to attempt simplification of terms and concepts by symposium discussions or conferences but mostly by sympathetic understanding. Professional vanity would not surely stand in the way, for nothing appeals so much to the heart of the true scientist as pursuit of truth.

8. Mr. M. N. Banerji, Calcutta.

Psycho-analysis is not the whole of abnormal psychology nor a representative sample of the latter before the rise of the former. Psychi-

atry and the physiological lines of approach to abnormal mental phenomena and non-psychoanalytic psychological study of them have thrown floods of light on general principles of psychology. All mental states whether they are cognised in the normal or the abnormal mind are natural All laws worth the name should be able to explain mental phenomena irrespective of whether we label them normal or abnormal from socio-behaviouristic point. From the stand-point of pure psychology, there is no such thing as normal or abnormal, therefore no necessity arises to prove formally that certain laws discovered in connection with the working of the unsoucd mind are of general applicability. Psycho-analysis was essentially a free association method thrust on the master mind of Freud by his patients and first applied to cure Hysteria and other neurosis. Freud gave a new orientation to the term 'Unconscious' out of vague and loose nebulous conjectures. The scope of psychology along that of the mind was extended and we came face to face with the kernel of Mind and the forces that worked there, the basic innate urges of self and Sex instinct and the 'Id'.

Psycho-analysis is not abnormal psychology at all. It is pure and simple depth or dynamic psychology. It is not a viewpoint but an extensive addition to the scope and method of psychology—pure and applied. What the Experimental Psychology of Wundtian school and its derivatives dealt with was only the conscious part of the mind and psycho-analysis deals with the unconscious portion. The two should be bridged as is being attempted in the Bengal school now under the President of this section.

Evaluation of contribution of other abnormal psychologists has been omitted in the leading paper. Wundtian Psychology and other schools based on it have not failed altogether. Their aim of psychology was not identical with the present day viewpoints of psychology. Behaviouristic school lays emphasis on the physiological explanation. Except psycho-analysis, Wundtian Experimental Psychology has done a great service. There is a very bright future for 'mental measurement' school. Gestalt psychologists by their new experiments on perception of movement and their emphasis on the whole have done real service.

9. DR. N. N. SEN-GUPTA, Lucknow.

Normal and abnormal psychology have been mutually influencing each other since a long time past. A survey of the process of interchange of concepts and insights between the fields of abnormal and general psychology shows that the former has influenced the latter in *six* principal ways: (1) It has drawn attention to several facts of normal psychology, e.g. dreams, day-dreams, etc. and has amplified the connotation of many others. (2) It has formulated certain interpretative concepts, e.g. the Unconscious, fore-conscious, Extroversion, Introversion, etc. (3) It has also formulated a number of relational concepts, e.g. condensation, Identification. etc. (4) Some new concepts have been introduced by it to normal psychology, e.g. the phenomena of suggestibility, attitude, disposition and others. (5) The Ego is defined in abnormal psychology in a more concrete setting than is common, e.g. in the schools of Wundt, James and others. Similarly the much misunderstood idea of Sex is better described in Freudian Psychology. (6) Lastly, abnormal psychology suggests a new method of approach to the psychological sciences. Psycho-analysis is the technique for the discovery of the phase of the total psychological patterns.

The methods of abnormal psychology are now fairly well-established. The mental states and behaviour of the abnormal are described in their phenomenal aspects. The phases of the total experience are observed and are so connected as to picture a unitary whole. This whole and its phases are correlated with: (1) the past experience, (2) the environment, (3) the physical condition. In the light of this knowledge the symptoms are explained and curative measures are devised.

The method of general psychology is conceived in a similar fashion. The mental processes and behaviour are determined by four sets of factors : (1) Antecedent conditions of the organism. Some of these are at time capable of discovery by self-observation ; other times they cannot be so discovered. (2) Bodily processes, including the hereditary trends, the character of the nervous system and the rest of the organs of the body. (3) Physical environment including (i) certain general factors such as altitude, climatic conditions, etc. and also (i) specific stimuli. (4) Social stimuli such as the number and nature of the social group.

10. Dr. S. C. Mitra, Calcutta.

Reply to the above discussion.

I am quite prepared to agree with Lt.-Col. Owen Berkeley-Hill, that taken in a very broad and general way there is no distinction between normal and abnormal psychology, because whatever happens mentally either in the sphere of what is regarded as normal or in the sphere of what is distinguished as abnormal is perfectly 'normal' in the sense of 'natural' event as under the circumstances nothing else could have happened. Had we lived only in the high intellectual sphere of pure abstractions and wide generalizations without the necessity of having any practical contact with our fellow beings there would have been no need to make any distinction between normal and abnormal, or for the matter of that between physics and chemistry, between plant and animals. But we live in a society and society makes incessant and multifarious demands on us. Unless we can meet these demands and adjust ourselves to the situation, we are sure to be driven to the wall. Useful modes of adjustment to particular situations soon develop and they become the standards of conduct. They come to be regarded as normal forms of behaviour. Anxiety is a normal psychological phenomenon, but it becomes abnormal only when it is out of proportion to the situation, i.e., when it leads to maladjusted behaviours. The primary necessity which urged us to make a distinction between normal and abnormal arose from our attempts at adjustment to social demands. So that the statistical-social seems to me to be the only acceptable sense of the term 'normal' which can be profitably pursued in psychology. Besides, how is the province of psycho-therapy to which Col. Berkeley-Hill refers, to be defined and what is health and what is disease ? Proper definition of these terms would inevitably lead to the concepts of adjustment and maladjustment.

I am glad to find myself in a position to accept all that has been said by Prof. H. D. Bhattacharyya, and would like to draw attention to the special emphasis that he has laid on the influence of the social environment on the development of individual behaviours, normal or abnormal. In drawing the distinction between normal and abnormal, he recognizes the social standard. He accepts that man is a creature of impulses and desires and that the normal and morbid reactions of men are all prompted by inner urges—many of libidinous character and all designed to fulfil this or that wish of a conscious or unconscious kind. He has no doubt about the importance of the contributions that have been made by abnormal psychology towards the understanding of crowd leadership, religious devotion, sociological phenomena of different kinds and kindred products of the individual and social mind. He has hinted at a probable philosophical background of the discoveries of the abnormal psychology.

Prof. Jamuna Prosad points out that all the schools of psychology to which I have referred, have made valuable contributions independently of the findings of abnormal psychology and takes me to task for denouncing all these schools and for my failure to consider the researches of Jung and Adler. The introductory portion of my address will convince anyone that it was far from my intention to denounce wholly every prevailing school of psychology. I have merely attempted to point out what appears

to me the shortcoming of these schools and I am sorry if it has created the impression of an out and out denunciation. I have not specially mentioned the researches of Jung and Adler not because I do not consider them valueless but simply because what is valuable in them has been incorporated in the Freudian system. Prof. J. Prosad seems to be very doubtful about any valuable contribution being made by psycho-analysis to normal psychology. He makes one grudging concession in favour of psycho-analysis to the effect that some older ideas of traditional psychologists, e.g. conative tendencies, voluntary actions, inhibition and self-control, which were fast getting sterile and lifeless, have been much widened, enriched and improved by psycho-analysis. He scornfully rejects the ideas of infantile sexuality and quotes in his favour, Stern, a recognized authority on Child Psychology. He easily disposes of Freud's theory of the origin of civilization and of totem and taboo by stating that these explanations are only 'master-pieces in the art of systematizing phantasies'. As there are no arguments to support these general statements I can only answer that I do not accept Prof. J. Prosad's characterization of these theories as master-pieces in the art of systematizing phantasies. He gives credit to Freud for recognizing recently that the 'Oedipus Complex' has passed away and the universality of the dictum 'the Oedipus Complex is the nucleus of neurosis' has been abandoned. He quotes Freud's statement regarding anxiety 'that everything here is in a state of flux'. If those statements are meant by Prof. J. Prosad to imply that the concepts of the 'Oedipus Complex' and the influence of anxiety on neurosis have been abandoned, I cannot accept his interpretations at all. Oedipus Complex may pass away in normal adults but Freud does not mean that the concept has ceased to be applicable to children. When he said that everything regarding anxiety was 'in a state of flux or change', he never intended to convey the impression that all that had been said before regarding anxiety should be absolutely given up. What he implied, as is evident from his lectures from which the above passage has been quoted and from his later book *Inhibitions, Symptoms and Anxiety*, was that the problem of anxiety needed further analysis. Prof. J. Prosad's charge against psycho-analysis that it has introduced 'mechanistic conception of mind' has been ably met by Dr. Purushottam. The latter has rightly asserted that before Freud there has been no psychological objectivity worth mentioning. I would have very much welcomed a detailed analysis of the developmental impulse to which Prof. J. Prosad refers.

I find myself in complete agreement with one of the main points of Dr. T. Purushottam's article, viz., that the hypotheses regarding the working of the mind which Freud has developed from his study of *Dreams* are applicable to the processes of normal mind. The scope of Freud's discovery remains general. He believes that the energy of the living mind is libidinal. His view that the new concepts of psychology will be more and more applied to Biology, Organic Medicine and other sciences, is one which I wholly subscribe to. His other point about objectivity has already been mentioned.

Prof. J. K. Sarkar thinks that all-prevailing schools of psychology have contributed something towards the progress of psychology. I do not differ from him and I fully agree also with his statement that all complex mental processes like memory, imagination, etc., that are developments of original sense-perception have their root in the Unconscious.

Mr. H. P. Maiti refers to the total impression conveyed by my paper about the worthlessness of non-analytical psychology. I certainly do not hold the opinion that other schools of normal or abnormal psychology have not contributed anything towards the understanding of the mental processes. What I contend is that psycho-analysis supplies the essential element that was missed by them. The discovery of the Unconscious has given an entirely new interpretation to the findings of other schools. I fully agree with Mr. Maiti that the difference between him and myself

is mainly a matter of emphasis. While he believes that psycho-analysis is only a 'school' among many others, I am inclined to consider it as the foundation of the Science of Psychology and the fundamental basis of all psychological thinking. I fully subscribe to the view that the discovery made by psycho-analysis of the social implications of our behaviour—overt or implicit—is very significant for the future reconstruction of social relations. By adding a very valuable appendix to his paper containing an analysis of the attitudes of the authors of the modern text-books of General Psychology and History of Psychology, he has shown how the principles of psycho-analysis are gradually being appreciated by them. He refers to some difficulties in the way of incorporation of psycho-analytical findings in general psychology. The chief difficulty is a methodological one. I fully appreciate his remark that one cannot ask a Scientist—in the present case the Psychologist—to accept a fact or theory relating to his science without verification for himself. I am glad to say that he himself has shown how the difficulty can be overcome. By his experiments on memory and reaction time he has demonstrated how the rapprochement between psychology and psycho-analysis can be made possible and how psycho-analytical findings can be put to test under traditional laboratory conditions. Another difficulty lies in the new terms and concepts of psycho-analysis which appear to be too cumbrous to many and to be substantive in their import. Psychology has been trying to get rid of the belief in the mental substantives and it is difficult for them to reconcile themselves easily to the new terms. I do not think that the difficulty is an insurmountable one and as he himself has suggested symposium discussions and conferences may in the near future lead to a simplification of the terms and concepts. It would surely be a calamity if conservatism, pedantry, or professional vanity stand in the way of such simplification.

Mr. M. N. Banerji seems to accept the socio-behaviouristic standpoint as the criterion of normality. I agree with him when he says that by the discovery of the language of the Unconscious, Freud explored the biggest realm of the Mind. As regards the points of dissension with me, I do not think that it would be relevant to go into the details of the prevailing schools of psychology in order to evaluate their respective contributions towards explanation of the mental phenomena. It was furthest from my intention to maintain that these schools have contributed nothing towards our understanding of the psychological processes. I refer him to the introductory portion of my article. It would have been better had Mr. Banerji defined what he precisely meant by 'depth psychology'.

Dr. N. N. Sen-Gupta generally agrees with what have been stated by me. He has, however, presented the materials in a very logical way, classifying the contributions of abnormal psychology under six different headings. His own view about the methodology of general psychology has throughout been of the nature suggested by the development of psycho-analysis.

11. Ernest Jones, London.

I must confess, parenthetically, to being one of those who feel a prejudice against the term 'Abnormal Psychology'. Few workers have been willing to reconcile themselves to the admission that their psychology is abnormal, and still less the risk of being themselves designated as abnormal psychologists. I should myself, for reasons that will presently be indicated, have preferred to use the term 'clinical psychology'. In England 'medical psychology' is the term most widely used, but it is possible that professional prejudice may have much to do with this preference. In this connection an interesting suggestion made some years ago by Wilhelm Specht may be recalled. He proposed to restrict the term 'psycho-pathology' to the study of abnormal mental phenomena carried out from a purely medical point of view, i.e., the investigation of

the causes, pathological significance, and modes of treatment of such states; and to use the term 'patho-psychology' for the investigation of the same data purely from the point of view of general psychology. Certainly this distinction is well worth nothing, for most of the interest attaching to the intensive study of pathological mental states that has been carried out in the past quarter of a century is clearly due to the startling extent to which knowledge gleaned in this field has been illuminating for other fields as well.

Now the simplest answer to the question of what the study of the 'abnormal' has contributed to the study of the 'normal' might well be given in one word: *the Unconscious Mind.* For this includes all else. It is a much greater gift than bacteriological knowledge was to the study of infectious disease or the circulation of the blood was to physiology. After all, important as the new knowledge was in these two cases, it concerned only one of many elements of the situation. Knowledge of the unconscious mind, however, is not merely an addition to our knowledge of the mind—the study of one more element; it represents the discovery of what the mind as a whole really is, an organ of which the conscious mind is only an external expression. Investigation of the unconscious has made it for the first time possible to begin to elucidate the significance of that external expression, to which 'normal psychology' has hitherto been confined—and on a purely observational level.

Instead of giving this short answer, however, I would expound the matter in the following way. The outstanding feature that most sharply distinguishes the clinical method, in either medicine or psychology, is that in it attention is concentrated not so much on the investigation of any particular system considered in isolation, or the elucidation of any particular disorder as such, as on the scrutiny of an individual *human being* considered *as a whole.* In this statement there are two important constituents, the stress laid on the words 'human being' and on the words 'as a whole'. The decision to make an intensive investigation of a number of individuals proved to be a much more fateful one than it must have appeared at first. The motive impelling the pioneers to make this decision was the necessity of doing something when confronted by the terribly urgent problem of suffering, and this motive enabled them to overcome just the obstacles that had hitherto been imposed in the way of any penetrating investigation of the mind. The history of the investigation of the body was repeated in the sphere of the mind. To examine the inside of the body had, for centuries, been forbidden as something taboo, not nice, not proper and not right. But the extreme desirability of learning something about what, why or when men suffered from disease at last broke down this prohibition. Examination of the inside of the mind was still longer held up, and mainly by similar obstacles. With this tradition most clinical psychologists have definitely broken. Faced with the grim tragedies of neurosis, they have had perforce to come to close quarters with the intimacies of emotional life, and, much to the horror of their contemporaries, they have proceeded to examine dispassionately the facts in this way brought under their notice.

A clinical attitude, studying the personality as a whole, is more concerned with the scientific problem of the relationship between mental processes than with the more philosophical problem of the ultimate nature of them. One of the outstanding conclusions to which this methodological mode of approach has compelled assent is that the various forms of mental functioning are extraordinarily interrelated and mutually dependent, so that justifiable scepticism arises in regard to such experimental work which professes to isolate such processes as intellectual or memory ones from the rest. This is only one of the many respects in which the clinical method has come into some degree of conflict with the older methods, though the history of science gives every reason to believe that such conflicts can only represent a transitional stage in the development of psychology as a whole.

But clinical psychology has far more to offer normal psychology than scepticism. It has also made positive contributions to our knowledge of a fundamental character. When the study of the mind is approached in this way, with a propensity to consider every problem in reference to the whole personality and with the resolve not to shrink from exploration or the inner mental life, however intimate, wherever necessary, experience shows that it will result in certain characteristic views being taken of mental functioning. These, then, come to be rather distinctive attributes of the clinical method. Four of them may be selected for special emphasis: they may each be memorized by a single word: genetic, dynamic, instinctual, and unconscious, respectively. A few words will be said about them in this order. It will be noticed that academic psychology gives its assent in general terms to three of them, to all except the idea of the unconscious, but they are all taken much more seriously and applied much more rigorously in clinical psychology.

Everyone would, of course, agree with the statement that the mind develops, but a great deal more than this is meant when it is said that clinical psychology views the mind *genetically*. Here the continuity of the mind at different ages is regarded quite literally. It is held that the significance of any given current mental process is not completely known unless the full genesis of it is also known, unless its predecessors can be traced back in an unbroken chain to the beginnings of mental life in the infant. It has been found that many of the older elements of the genesis, and often the most important of these, are not completely transformed into or replaced by their successors, so that a certain amount of their original significance is still retained. The practical effect of this is that many of our impulses, interests, and ideas carry with them an extrinsic significance based on their genetic history, that they represent more than what they purport to. In extreme cases, of which unconscious symbolism is the most striking example, the subject is totally unaware of this surplus significance. The most advanced school of clinical psychology, following Freud, carries this genetic principle to its logical conclusion and maintains that all our later reactions in life are really elaborations of simpler ones acquired in the nursery. The power to modify the more fundamental types of reaction becomes rapidly less as the child grows, and some of us even think that no fundamental change in character can take place after the fourth year of life.

In its *dynamic* view of the mind, clinical psychology comes into decided opposition with the old associationist psychology. When one mental element occurs after another it is no longer possible to think we have explained this by saying that the second element, having been attached to the first through temporal contiguity, or inherent similarity, was aroused by the presence of the first. Dynamic factors such as those designated by the words motive, tendency, purpose, impulse, are sought for in every single instance, however minute, and no explanation is regarded as adequate unless a factor of this kind is demonstrated. This holds even with mental events, such as slips of the tongue and the like, that previously were supposed to 'happen', without any ascertainable reason, and certainly without any motivation. Yet the older views die hard in some fields of work—for instance, in regard to dreams.

A through-going dynamic conception of mental events as essentially the expressions of the interplay of various 'forces' leads to many important consequences. One comes, in this way, to realize that a great number of mental processes come about as compromise-formations, various conflicting forces having contributed to the end result. From the work of clinical psychologists the extent to which conflict between opposing tendencies takes place in the mind, and the importance of such conflicts, is gradually becoming recognized. It is not simply a question of their frequency. Far more important is the matter of their invisibility. There are in fact extremely few expressions of the mind that are pure manifestations of a single impulse or trend. What appear to be so mostly turn

out on investigation to be either a compromise between two or more opposing ones in the unconscious or else a defensive reaction on the part of one trend against another, repressed one. In other words, man is far less of a free agent than he thinks. Most of his activities, interests and opinions proceed from unconscious sources, without his having any inkling of the fact, and are—so to speak—forced on him. This applies even to the more permanent attitudes of mind and character traits, which are usually defences necessary to him as safeguards against repressed and feared impulses. An interesting and important aspect of this knowledge is that there is far less true thinking done than is generally imagined. Most of what passes for thought is rather the fortifying of some prejudice or opinion that is necessary to peace of mind or mental balance.

As befits a discipline of medical origin, the clinical attitude is close to the biological one, and most clinical psychologists feel that one of the chief goals of their work is to be able to state their mental data in biological terms, i.e., in terms of the *instincts*. It has cleared the ground by showing that a number of supposedly inborn instincts with which other psychologists had operated are complex products, and so are capable of resolution into more primary elements. In the second place, the analyses effected by clinical psychologists, particularly by Freud, of the conative aspects of the mind have revealed much of importance concerning the development, manifold fate, and products of the instinctual side of mental life, and it is reasonable to expect that further research along these lines will bring us nearer to the ultimate sources of mental impulse.

This attitude of clinical psychology to the instinctual basis of mind is in harmony with the changed attitude concerning man's place in nature that was brought about by the biologists of the last century. It is in short an extension of the evolutionary view of man into the sphere of the mind, the sphere where, in spite of some tentative efforts of Darwin, those biologists were not yet able to apply the doctrine of evolution. The clinical attitude thus represents a developmental view, not only ontogenetically but also phylogenetically. The psychology of the 'normal', on the other hand retains much of the philosophic basis given it when it was regarded as being entirely distinct from the animals, and has never been truly permeated by the biological view.

Of the *unconscious* I have already spoken. The discovery of its contents and characteristic mechanisms constitute, not a mere contribution to psychology, but a revolutionary change in psychology. One now sees the mind afresh, not as a relatively smooth-working machine, but as a complex of subtle defences against the anxiety aroused by the impinging of primitive impulses on external reality, i.e., human relationships.

One of the disconcerting conclusions to which one is compelled by the study of clinical psychology is that, strictly speaking, there is no such thing as a mentally normal human being, i.e., one whose mind has followed a direct path of development. The so-called normal and abnormal mainly represent different modes of reaction to fundamental difficulties in development and adaptation. The fallacy of thinking that the 'abnormal', by which I mean essentially the neurotic, not of course mental defects from organic origin—have anything to do with disease in the ordinary sense has long been exposed. There are moreover good reasons for thinking that the path of development in the 'normal' is much more tortuous and circuitous than in the 'abnormal'. It may sound paradoxical, but I venture to predict that in a not far distant future psycho-pathology will constitute a standard study of psychology, the basis from which the student will proceed later to the more obscure and difficult study of the so-called normal.

There are two objective grounds why this prediction is a very safe one to make. Investigations of the deeper layers of the mind has shown that the basic elements out of which our minds are developed persist with the psycho-neurotic—in the unconscious, it is true—in their original form to a much greater extent than they do with the normal, and further that they present themselves in a magnified and perspicuous aspect as if under a

clear lens, so that from every point of view they are far more accessible to examination there than with the normal. Fundamental complexes, drives and mechanisms, the effects of which radiate throughout the whole mind, can be very plainly demonstrated in the psycho-neurotic when the same processes can often be only dimly inferred in the 'normal'.

The second ground on which the prediction can be based is even more interesting. We know now-a-days that the reason why psychology has lagged so extraordinarily behind all other branches of science is because there exist in the mind—both, be it noted, of the subject and of the object—the most formidable obstacles which interpose themselves in the path of any exploration designed to penetrate below the surface. Unlike any other man of science, therefore, the psychologist is from the beginning to a large extent cut off from the object of his study—the human mind. So far as our present experience goes, there is only one motive strong enough to overcome these obstacles—that of wishing to be delivered of suffering; even the keenest scientific curiosity offers only a very partial substitute for this motive. Now in the history of the world the theme of suffering has been the special concern of three classes of men: of poets, of priests, and of physicians. Until recently it has been the first of these three, the poet, who has contributed most to our understanding of mental suffering, and we owe some of our most precious insight to his flashes of genius. But he is, after all, primarily concerned, not with the understanding of suffering, but with the transmuting of it into beauty or whatever else would raise it to another plane.

The priest's interest, too, has been mainly therapeutic. Starting with a vested interest in a particular cure, he has been chiefly engaged in transmitting his cure to those in need. Nevertheless, the more profound theologians have also furnished us with much knowledge concerning the nature and sources of suffering. They have rightly led especial stress in this connection on the importance of moral problems, notably on the problem of sin—now-a-days called the problem of the sense of guilt. The physician likewise did not proceed very far so long as his attitude was a purely therapeutic one, showing once more how the passion for therapeutics—laudable as it is on humanitarian grounds—has often proved the bane of medicine and has blocked progress in real prevention and cure based on knowledge. Those over-anxious to heal cannot pause to find out how to do so. It was only when the desire to relieve suffering was infused by the scientific thirst for knowledge that we began to have serious insight, not only into the meaning of all this suffering, but—what is still more important—into the dynamic factors that move both the depths and the surface of our minds. In this achievement there is, in my opinion, one man's name that will for ever be pre-eminent, and that is the name of Freud, now so condemned, but in the future to be honoured above all his contemporaries.

12. S. C. Mitra's Further Remarks.

I have already communicated my views to the individual participants of the symposium regarding the points raised by them in their respective papers. I think it would be better for all, particularly those who have not as yet taken part in the symposium and who would like to join in the discussion that will presently follow, if the various issues raised be presented in a summarized form. This is what I propose to do now. I shall also add some general remarks to the answers that I have already given.

1. The first point that I would like to refer to concerns normality and abnormality. With regard to this, two questions have been raised: (*a*) whether any distinction should at all be made between normal psychology and (*b*) if so, what should be the criterion for determining normality and abnormality. (*a*) As to the first question, my view is that in the present state of our knowledge the distinction between normal and abnormal psychology must be maintained. I am quite prepared to

admit that by dint of *sadhana* (yogic practices) a stage of *purnajnana* (perfect knowledge) may be attained in which differences disappear altogether and contradictions cease to exist. It will readily be granted, however, that such a stage of knowledge is not going to be within an easy reach of average mortals like the majority of us in the immediate future. It is not therefore unreasonable to assume that differences and distinctions will continue to exist in this imperfect world of ours and consequently normal psychology will continue to be differentiated from abnormal psychology for a long time to come. How then should normality be distinguished from abnormality? This brings us to the second question, viz., the question of the criterion. (*b*) In a paper read before the Indian Psycho-analytical Society, Maiti gave us an admirable resume of all the prevailing views about normality. He pointed out also that up till now psycho-analysis has not attempted to set up any standard of its own for determining the characteristics of normality. It seems, however, that psycho-analysts as well as others have generally employed the social criterion first explicitly formulated in language by Bose. In deciding about the normality or otherwise of human conduct and behaviour, I do not think any other standard but harmony with the prevailing social ideals of the time and place will lead us anywhere. Taken in a broad sense maladjustment beyond certain more or less arbitrarily specified limits may be put down as the only useful criterion of abnormality. Even bodily diseases can then be shown to be but cases of maladjustment between organs and functions.

2. Another point which has been emphasized by many participants is that all schools of normal and abnormal psychology have contributed towards our understanding of mental phenomena. Some have gone into details of different schools of psychology and psychiatry in order to point out the contributions that have been made by them towards understanding human nature.

I am sorry that my article has created an impression that I consider all schools of psychology besides psycho-analysis as worthless. It has never been my intention to deny that other schools of psychology and psychiatry have made valuable contributions towards the solution of psychological problems. In fact, I myself have published papers expressing my views and appreciation of some of the schools of psychology. I fully believe that all the schools help us to understand many of the conditions of mental events and the construction of the mental structure, but what I am inclined to think is that the essential elements is missed by them all. I cannot do better than quote in this connection the beautiful illustration given by Freud himself. 'Just suppose that on some dark night I am walking in a lonely neighbourhood and am assaulted by a rogue who seizes my watch and money, whereupon, since I could not see the robber's face clearly, I make up complaint at the police-station in these words, "Loneliness and darkness have just robbed me of my valuables".'[1] The essential thing to be done is of course to look about for the thief. That is, if I may say so, what psycho-analysis does while other schools of psychology concern themselves mainly with the loneliness or the darkness or with the gestalt loneliness-darkness. I purposely refrain from discussing the merits and demerits of the various schools of normal psychology since as is pointed out by Jamuna Prosad 'the subject-matter of our discussion is not the contributions of normal psychology to abnormal psychology but the reverse'. As regards the schools of psychiatry I don't think that I shall be wrong if I say that the improvement in the outlook and methods that is now noticeable in them, is mainly due to the influence of psycho-analysis. I repeat that I have not separately mentioned Jung, Adler and others' contributions as I believe that valuable factual meterials of these researches as distinguished from the philosophy underlying them, have been incorporated in the psycho-analytical system.

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[1] Freud—*Introductory Lectures on Psycho-analysis*, p. 35.

3. Now I come to the third point, viz., the so-called pan-sexualism of Freud which, I notice, has been raised by only one of the participants. I must admit that I was rather surprised to find this old objection brought out anew. The point has been discussed threadbare in psycho-analytical literature and the erroneous conception about the term sexuality which lies at the root of this objection has been fully exposed. To be shocked at the term 'polymorphous perverse' is perhaps an indication of intellectual and cultural aristocracy and I cannot of course ask anyone to lose his sense of respectability even if that means merely giving up untenable theories and accepting what the logic of facts inevitably leads to. The present objector belongs to the state described as the buffer-state between analysts and their opponents and I follow the advice given by Freud by not entering into polemics with him. Authority is certainly a valid method of proof in many cases but in the face of the outstanding factual evidences collected in a thoroughly scientific manner by distinguished and patient workers, I shall be pardoned I hope, if I do not find my way to accept the opinion of Stern quoted by him, and to reject unceremoniously like him the concept of infantile sexuality.

4. The next point raised concerns Freud's interpretation of art, religion and other cultural products. It is only to draw attention to the fact that in circles which are expected to be well informed, gross misconception about psycho-analysis still prevails that I have referred to this point. I am glad to say that the majority of the participants who have referred to this topic, realize the importance of the contributions made by psycho-analysis towards understanding these cultural products. One gentleman however the critic just referred to has characterized Freud's theory regarding these as 'masterpieces in the art of systematizing phantasies'. In the first place I contend that phantasies have an importance of their own and have a legitimate place in the intellectual and practical lives of men. Before the Taj had materialized in marble on the bank of the Jamuna it had its ideal existence in the phantasies of the Great Emperor. In the second place, I maintain that they have a due part to play in the hypotheses of every science, even of such objective sciences as physics and chemistry. The progress of science is but the gradual concrete realization of phantasies. Lastly, I would point out that the objector has thoroughly failed to appreciate and has therefore completely ignored the patient and painstaking investigations that lay at the root of these theories. In one of his lectures Freud said, 'I have often had the impression that our opponents were unwilling to consider this source (viz., particularly difficult, intense and all-absorbing works) of our statements, as if they looked upon them as ideas derived subjectively which anyone could dispute at his own sweet will'.[1] The lecture was delivered in 1917. It is to be regretted that I have still to refer to this statement of Freud in 1938. As the heart of a frog that is decapitated, still continues its throbbings; old objections, it seems, though robbed of their essential elements, still continue their periodic walking in and walking out of the stage. The audience is amused at their persistent entrances and exits but is not inclined to take them seriously.

It is not Freud and his followers alone who have detected the sex-element in art. 'During the ascent through the animal kingdom an important displacement in the fundamentals of the procreative instinct has taken place. The mass of the reproductive products with the uncertainty of fertilization has more and more been replaced by a controlled impregnation and an effective protection of the offspring. In this way part of the energy required in the production of eggs and sperma has been transposed into the creation of mechanism for allurement and for protection of the young. Thus we discover the first instincts of art in animals used in the service of the impulse of creation and limited to the breeding season . .

[1] Freud—*Introductory Lectures on Psycho-analysis*, p. 208.

It can be a surprise only to those to whom the history of evolution is unknown to find how few things there are really in human life which cannot be reduced in the last analysis to the instinct of procreation.' The above is a quotation not from any of Freud's books but from the *Psychology of the Unconscious* (p. 80) written by Jung whose theories because of their freedom from the so-called sex bias seem to hold a greater sway over the objector's mind.

I do not understand why any botanist who has learned about the process of fertilization, etc. of plants, should lose his power of appreciating the beauties of flowers. Had there been any necessary connection between scientific knowledge about the origin of things and power of appreciating them, the physicians, I think who are intimately acquainted with the anatomy and physiology of the human body, would have been the least susceptible to the charms of the feminine beauty. Experience, however, does not confirm such an ungallant view about physicians. An ounce of research work in the field of arts and æsthetics of the type undertaken by Freud,[1] Jones,[2] Sachs,[3] Warburton Brown,[4] Haldar[5] and others is certainly worth more than a ton of moral denunciation by ameteur critics.

In his book *The Origin of the Sense of Beauty* (published in 1908), Felix Clay says, 'The emotion of sex is one of the emotions that plays a highly important part in art feeling . . . Those who have renounced love, and devoted their lives to religion or art, have still this powerful instinct (sex instinct) acting as an impelling force, though it may take forms in which the direct connection is difficult to trace . . There is an exhilarating fascination in talking to or even seeing, a beautiful woman, that is in a way not unlike the effect of a work of art'.[6] Herbert Spencer who cannot certainly be assumed to have been spoiled by the Freudian system of thought, pointed out 'that the greater part of what we call beauty in the organic world is in some way dependent upon the sexual relation . . . It is interesting, too, to observe how the conception of human beauty is in a considerable degree thus originated. And the trite observation that the element of beauty which grows out of the sexual relation is so predominant in æsthetic product . . . in music, in the drama, in fiction, in poetry . . . gains a new meaning when we see how deep down in organic nature this connection extends'.[7] I may also mention here that in an experiment conducted by me the surprising fact revealed itself that even such simple experience as æsthetic preference for lines, curves and other forms was determined to a large extent by reference to the human body.

The bringing into relation by Freud of such an ennobling cultural product as religion with such a gross physical matter as sex has given offence to the same participant. Besides referring to the observations that I have made just now with regard to the criticisms of the psycho-analytic theory of art. I may add that psycho-analysts are not the only guilty and gullible persons who have been struck by the sexual significance of many of the forms of religious practices. In an excellent treatise, Simpson Marr, a graduate in Divinity, has considered in details the relation

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[1] Freud—'The Relation of the Poet to Day-dreaming,' *Collected Papers*, Vol. IV, pp. 173–83.

[2] Jones—'A Psycho-analytic Study of Hamlet,' *Essays in Applied Psycho-analysis*, pp. 1–98.

[3] Hans Sachs—'Aesthetics and Psychology of the Artist,' *Int. J. P.*, Vol. II, pp. 94–100.

[4] J. Warburton Brown—'Psycho-analysis and Design in the Plastic Arts,' *Int. J. F.*, Vol. X, pp. 5-28.

[5] R. Haldar—'The Working of an Unconscious Wish in the Creation of Poetry and Drama,' *Int. J. P.*, Vol. XII, pp. 188–205.

[6] *Op. cit.*, p. 101.

[7] H. Spencer—*Principles of Biology*, Vol. II, p. 253.

between sex and religion from various standpoints. He mentions that William Blake considered religion to be merely the corruption of sex. D. L. Lawrence 'bitterly attacked the Church and the clergy for the attitude they adopted towards sex ',[1] and perhaps driven to extreme 'by the narrowness and futility of the Church with regard to this great theme he sought to make of sex a new religion and he went so far as to say that the way to find God was to find Him through woman'.[2] One of the noted writers and critics of the modern times C. E. M. Joad who is perhaps further away from psycho-analysis than our present objector, has in one of his books, discussed at some length Freud's theory of the origin of religion. After pointing out where he differs from Freud he concludes 'with most of what they assert I am largely, if not entirely, in agreement. I think that the interpretations they give of the origin of religion in terms of the needs which it fulfils, and grounds of its appeals in terms of the wishes that it rationalizes, are in the main true '.[3]

I refrain from quoting passages from other eminent thinkers of the age, like Bernard Shaw, Bertrand Russell, etc., who have appreciated the fact what the codes of religion are somehow intimately connected with the ways of sex. What the psycho-analysts have attempted to do is merely to make a scientific study of this intimate connection and to elucidate the points of contract. In this attempt they have created a host of antagonists. The opponents have taken every possible opportunity attacking the analysts from their vantage ground of aristocracy and respectability. Unfortunately their objections and rejections are not always based on an examination of the materials and so even when they are convinced against their will about the truth of the psycho-analytical findings they still prefer to cherish their old previous opinions. Even if the studies by eminent anthropologists and antiquarians of the various forms, rites and customs of religion of the primitive people be left out of account, an unbiassed critical and historical study of the rise and development of any religion will, I am sure, sufficiently make out a case for the fact that sex is one of the most important basis of religion and will thus corroborate the psycho-analytical interpretation.

It has been pointed out by Freud himself and many other writers on several occasions before, that the objections of the type cited above to infantile sexuality and to the connection of sex with art, religion and other products of culture generally arise from a misconception of what is meant by sexuality in psycho-analytical literature. It is, of course, difficult to give a precise meaning of the term 'sexual'. In psycho-analysis, the term has got a wider connotation than the popular meaning of it. In popular view sexuality means something improper and something connected with reproductive function. A little logical consideration together with psychological examination of collected facts will clearly convince anyone that this view is an unnecessarily narrow conception. It is a credit to psycho-analysis that it has restored to the word sexuality its true breadth of meaning.

5. I shall now touch upon the question of anxiety and Oedipus complex which have been raised. Says one of the participants 'credit must be given to Freud for recognizing recently, this much at least, that Oedipus complex has passed away and does not exist in the normals and greater credit still for his more recent assertion even in regard to the neurotics, that " we shall have to abandon the universality of the dictum that the Oedipus complex is the nucleus of the neurosis ".' He regrets that the followers of Freud 'still stick first to the old and abandoned ideas of their leader and are too slow to follow his pace of progress '. In reply, I think, I must first of all congratulate Freud for the felicitation that he has received

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[1] Marr—*Sex in Religion*, p. 15.
[2] *Ibid.*, p. 15.
[3] Joad—*The Present and Future of Religion*, p. 124.

from the participant. In the next place, I must admit, that I have not been able to follow precisely what exactly is the point that has been stressed so much and for which credit has been given to Freud. Bose's recent studies seem to show that even in normal persons Oedipus complex does not really pass away. Even accepting the ordinary meaning of Freud's statement 'Oedipus complex has passed', I do not think that Freud thereby advises his followers to give up the conception of the Oedipus complex altogether. When I say that the childhood of my friend has passed, I certainly do not mean that his childhood never existed and that like Sukdev of the Puranas he was born a full grown adult with mature wisdom. Probably, like the world famous critic referred to by Freud in his *New Introductory Lectures on Psycho-analysis*, my friend here is labouring under some misconception. The critic said to Freud, 'I am only a literary man, and you are a man of science and discoverer. But there is one thing I should like to say to you: I have never had any sexual feeling for my mother'. Freud replied, 'But there is no need at all for you to have been conscious of it, such processes are unconscious in grown-up people'. 'Oh so, that's your idea,' said the critic greatly relieved and pressed Freud's hand. It is my hope that one day our present objector as also many others like him, provided they patiently pursue their study of psycho-analysis in the proper scientific way will similarly feel greatly relieved and say, 'Oh so, that's their idea'. It must be admitted also that changes have been recently introduced and modifications made in the system of ideas that were so long current regarding the origin and states of anxiety. Here too we should not fall into the error of supposing that all that have been said heretofore regarding anxiety should be scrapped altogether and that we should have to start again with a clean slate. In one of his latest books *Inhibitions, Symptoms and Anxiety* (published 1936) says Freud, 'there is no need to be discouraged by these emendations in our theory. They are to be welcomed if they do something towards furthering our knowledge, and they are no disgrace to us so long as they enrich rather than invalidate our earlier views . . . by limiting some statement, perhaps that was too general or by enlarging some idea that was too narrowly formulated'.[1] It will thus be seen that neither the concept of the Oedipus complex nor the concept of anxiety has been given up, rather both have received deeper significance.

6. I next come to the doubt that seems to be entertained by some about the scientific nature of psycho-analysis. The theories of psycho-analysis, they maintain, are not capable of being verified by laboratory experiments and hence they hesitate to accept psycho-analysis as a scientific discipline. I readily agree that experimentation in the above sense is difficult to perform in the field of psycho-analysis. Maiti has shown that though difficult it is not impossible to devise suitable laboratory experiments in order to test the validity or otherwise of psycho-analytical findings. I think, however, that laboratory test should not be considered the only criterion of deciding about the scientific nature of a discipline. Experiments are not possible in many of the recognized sciences, but nobody denies their scientific character. Close systematic study of facts patiently collected and minutely observed and logical treatment of the data, these are the essential characteristics of a science. I am yet to find a person who has gone through the writings of Freud and has not been struck by his patience in the collection of facts, his unprejudiced scrutiny of the materials and the solid foundations of his theories. To depend on experiments alone in estimating the scientific character of a branch of study is to betray a form of intellectual weakness which has been very aptly described by Franz Alexander. Referring to the modes and virtues of modern research he notes the danger that confronts the scientific workers of the present day. Says he, 'This danger is not restricted to scientific

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[1] *Op. cit.*, p. 148.

laboratories, it is a general problem of the present age. Man, the inventor of the machine, has become the slave of the machine: and the scientist in developing highly refined methods of investigation has become not the master but the slave of his laboratory equipm . . . . A naive belief in the magic omnipotence of the technical procedure leads to a routine, often sterile submersion in details without interest in or understanding of larger connections '.[1] It is this attitude that leads many to regard 'suspiciously everything that entails reason and not merely observation' and to be, he continues, 'comtemptuous about theories, not to say hypotheses, that are yet not proven. There is a naive adoration of "pure facts" which are collected without any leading ideas '.[2] So even though psycho-analytical theories may not be subjected to the control of the laboratory technique I do not consider that the scientific character of psycho-analytic procedure is thereby prejudiced in any way.

7. A difficulty in the way of rapproachment between psycho-analysis and psychology has been pointed out specially by Maiti. Psychology cannot easily give up the terms and concepts that it has arrived at by the fruits of its labour for centuries and cannot readily assimilate the new technical terms of psycho-analysis. I feel the difficulty to be a real one. A way should be found to get over this difficulty. Perhaps conferences and symposium discussions will be able to render help in this respect, provided there be no mutual suspicion between academic psychologists on the one hand and the professed psycho-analysts on the other. I am doubtful, however, as to whether symposium discussions, as has been suggested by another, will be able to decide about the truth or otherwise of a particular psycho-analytical theory, because I feel that in such discussions moral and other extra-psychological considerations are likely to create unnecessary obstructions.

8. I am surprised that psycho-analysis has been accused of doing a positive disservice to psychology by introducing mechanistic conception. One of the fundamental conceptions of psycho-analysis is dynamism and if psycho-analysis has rendered any service to psychology it is its emphasis on the dynamic aspect of mind that should be given a pre-eminent place. The nature of this dynamism has been very well expressed by another participant who has said that before Freud there was no psychological objectivity worth mentioning and that 'objectivity in psychology is achieved only when the object of psychological study is grasped as the living Mind what lives on more than food, what shapes and uses the instrument of its action and grasps all things of the world for the sweetness thereof'. If it be deterministic view of mind that is sought to be assailed by the statement I have only to point out that determinism lies at the root of all sciences and psycho-analysis cannot claim any conception.

9. Seeing that psycho-analysts explain the custom of burial as a return to the mother's womb, they have been challenged by one of the participants to give a psycho-analytical explanation of the custom of cremation. I frankly admit that I have no ready-made explanation to satisfy him, neither do I know of any explanation of this custom in current psycho-analytical literature. There is no death of men of poetical and fanciful imagination among psycho-analysts and if psycho-analytical theories are nothing but systematization of phantasies it is rather curious that no one has yet waved into a theory of cremation.

10. These are the main points that have been stressed in the symposium articles. Before concluding I would like to mention one other point which concerns me personally. When the President of the Psychology Section requested me to open the symposium, I confess that I felt nervous because of the vastness of the task that was entrusted to me. To en-

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[1] Alexander—Introduction to Mortimer Adler's work, *What Man has made of Man*, p. ix.

[2] *Ibid*., p. x.

compass within a space of ten type-written pages all that can be said about contribution of Abnormal Psychology to Normal Psychology is certainly a difficult problem. After due consideration I thought that it would be best under the circumstances to confine myself only to broad general problems and to begin with a short introduction, briefly touching upon the other prevailing schools of psychology. That is the reason why I have not gone into details either of any school of psychology or of any particular problem. My thesis was and still is that it is psycho-analysis that metamorphosed academic psychology and has made the latter a living science. I have tried to the best of my ability in the original paper as also in my subsequent statements to present evidences for my thesis. I may mention that in this effort of mine I have only attempted to supplement what has already been given expression to by Bose in his article on *Psychology and Psychiatry* (I. J P., Oct., 1931) and Maiti in his *Concept of the Unconscious in the Mental Processes* (Pro. 4th Phil. Cong., 1930, p. 341).

OBSERVATIONS BY OTHER PSYCHOLOGISTS.

Lt.-Col. J. E. Dhunjibhoy's reference to concrete cases proved highly amusing as well as instructive. Dr. N. N. Sengupta and Dr. Indra Sen emphasized the methodological aspect of the problem, while Prof. H. D. Bhattacharyya stressed the social point of view in the determination of normality. Dr. Purusottam referred to the contribution made by Prof. Spearman. Dr. N. S. N. Sastry pointed out that ancient Indian Psychology recognized the importance of 'Kama' in the mental life of man. Dr. S. K. Moitra also drew attention to researches in ancient Indian Psychology, Messrs. U. S. Gheba and S. P. Aranya and others took part in the debate. The new points raised were answered by Dr. S. C. Mitra and the discussion was finally summed up by Dr. G. Bose.

XIX. THE APPLICATION OF STATISTICS IN AGRICULTURE.

(Section of Agriculture, in co-operation with the Indian Statistical Conference.)

[No report of the discussion has been received.]

XX. RECENT ADVANCES IN MOLECULAR STRUCTURE FROM THE PHYSICO-CHEMICAL STANDPOINT.

(Sections of Mathematics and Physics and Chemistry, in co-operation with the Indian Physical Society.)

1. DR. K. N. MATHUR, Lucknow.

   Magnetism in relation to molecular structure.

2. DR. MATA PRASAD, Bombay.

   X-Ray and molecular structure.

3. DR. R. K. ASUNDI, Aligarh.

4. DR. P. N. SEN-GUPTA, Kohlapur.

5. DR. H. K. TRIVEDI, New Delhi.

6. DR. D. M. BOSE, Calcutta.

7. DR. K. S. KRISHNAN, Calcutta.

8. DR. S. N. BOSE, Dacca.

[No report of the discussions has been received.]

XXI. THE POSITION OF ENTOMOLOGY IN THE INDIAN UNIVERSITIES.

(Sections of Zoology and Entomology.)

A joint discussion on 'The position of Entomology in the Indian Universities' of the sections of Zoology and Entomology was held in the Zoology section (Chemistry Room I, Presidency College, Calcutta) on January 7, 1938, at 11 A.M. under the chairmanship of Prof. G. D. Hale Carpenter, Oxford.

1. MR. M. SHARIF, Aligarh.

The importance of Entomology to Agriculture, Medicine, Veterinary and Forestry, and the rapid advance that has taken place during the past 30 years reveals a changed outlook. It is desirable that the teaching of Entomology should be placed on sound footings. Separate Departments of Entomology independent of Zoology should be started in the Universities. Entomology should be given an equal status with Zoology and Botany. It is, however, essential that an advanced student in Entomology has a good foundation of Zoology but if the Departments of Entomology are not separated from Zoology, then there is danger of Entomology being ignored, as is happening to-day in the Indian Universities.

2. MR. DURGADAS MUKERJI, Calcutta.

Insects play a very important rôle in the life of an agricultural and tropical country: (i) in health, (ii) in agriculture as pests of crops, etc. and in pollination of flowers, (iii) in cottage industries—sericulture, apiculture and lac.

Besides, Entomology presents scope for problems of wide scientific interest—adaptation, colouration, mimicry, genetics, etc. etc.

The vastness of this science necessitates its study as a full subject. India offers problems of applied value which require trained Entomologists to study. Entomology should be included as a special subject at the post-graduate stage of the Zoology course.

At present provision for teaching and research in advanced Entomology in Indian Universities is meagre.

Agricultural Institutions should not be burdened with the teaching of advanced Entomology, which should be the duty of the Universities.

Co-operation between Universities and Agricultural and Medical Institutes is necessary for the teaching of advanced Entomology.

3. Dr. D. P. Raichoudhury, Calcutta.

As compared to the Universities in Europe, America and Japan the position of Entomology in the Indian Universities is disappointing. Applied Entomology has an important bearing on improvement of agriculture in India.

Separate Entomological Departments should be established in Universities and senior Zoology students taught advanced Entomology with particular reference to applied Entomology.

Encouragement should be given to teachers and students to take up Entomological investigations.

Special attention should be paid to problems connected with sericulture, apiculture, lac industry and insect pests of fruit, vegetables, stored products, timber and tobacco. Business men connected with these industries should be brought into closer contact with the Universities for mutual help.

4. Dr. Hem Singh Pruthi, New Delhi.

The present position of Entomology in Indian Universities and courses in Agricultural College. Post-graduate training at the Imperial Agricultural Research Institute and elsewhere. Difficulties in finding students with adequate fundamental knowledge of the science of Entomology. Post-war development of Entomology in European and American Universities. Place of Entomology in a Zoology course for the degree examination and in post-graduate work. Need for trained Entomologists. Scholarship for post-graduate training—Indian Central Cotton Committee, the Imperial Council of Agricultural Research and Universities to provide these.

5. Dr. P. Senior-White.

I am only intervening in this discussion of teachers of this subject, because I have under me about a dozen posts in what is really no more than applied Entomology. When I started, *ab initio* the Malaria Section of the Medical Department of my Railway, the finding of subordinate staff presented great difficulties. Naturally, I started with the qualified Sanitary Inspector. I found, in this country, that his knowledge of Entomology from his course consisted in telling an Anopheline from a Culicine larva. He could not use a dichotomic key and has no familiarity with a microscope. [All malaria control under me is strictly by species and involves larval and adult identification . . . .] I then tried the Sub. Asst. Surgeon, and found him equally ignorant in all those aspects. Gradually other types of applicants approached. The B.Sc. (Agric. or Zoology) can use a microscope, and a key, and quickly learn the common forms of culicid systematically on which malaria control is founded. I am now giving preference to applicants so qualified.

But, malaria control is not pure Entomology. It involves some acquaintance with Botany and other Sciences, involved in Ecology, which would not be available if a man has specialized throughout his University career in Entomology only. I therefore suggest that a basic training in general zoology, prior to specialization in Entomology, should not be departed from. But, as training in Malariology at Karnal, Shillong, is confined to those with a medical qualification, I would urge that some Indian University make a similar course to Karnal available to the Zoologist.

6. Prof. B. K. Das, Hyderabad.

Entomology is a growing science and is of utmost importance to the national welfare of India. It should be taught as special subject in the Post-Graduate classes in the Universities. Where there is a department

of Zoology a Reader or a Lecturer in Entomology should be appointed—in a word, it should be a special part Zoology.

7. Dr. S. Pradhan, Lucknow.

The importance of Entomological studies is undoubtable, unquestionable and immensely great and any amount of repeated stress on this point is not out of place.

Entomology as part of Zoology Course:—In the study of zoology we have to do equal justice to the whole of the animal kingdom and the animal kingdom consists of so many phyla and each phylum consists of so many classes; thus out of a very large number of classes the class Insecta is only one. The student of Zoology, therefore, can afford to devote a negligibly small portion of his time and energy to the study of Insects, as from the pure knowledge point of view all classes are regarded of equal status and some times a single genus like *Peripatus* constituting a separate class is given more attention than the whole of the insect world. It is therefore absolutely impossible to do full justice to Entomology until and unless it is raised to an equal status to the rest of zoology. As a justification for this suggestion reference may be made to the study of Metcalf and Flint (Destructive and Useful Insects) which graphically shows that the number of the known species of insects is many times larger than the total number of the rest of the species of the animal kingdom. Even from the purely academic point of view, therefore, it should not be regarded as being unjustified to demand an equal status for Entomology.

The Attitude of the Universities:—The next question is as to what attitude the Universities should adopt under the present circumstances, i.e. so long as Entomology is not raised to an independent equal status due to financial and other difficulties. In this connection I may refer to the practice followed at Lucknow. In this University, the provision is such that if a student decides in time to specialize in Entomology (also in other groups) he is allowed one full year, after the Honours course to devote exclusively to the study of insects. In this year he is expected to specialize in insects for the M.Sc. degree, i.e. to make a general study of the various aspects of Entomology and thus to prepare himself for a more intensive work in any particular problem. As to how far this practice is beneficial or otherwise this distinguished gathering can best decide, but as a student of the same system I may give my evidence that this is very useful practice. To be allowed to devote one full year to general Entomology before confining to any particular problem is very useful from the student point of view, and if the other Universities encourage this practice they will be doing their duty at least in some measure, to this important science of Entomology.

Difficulties in Entomological Studies:—It is an absolutely established fact that due to the absence of reference collections, Taxonomic work is an utter impossibility in most of the Indian Universities. The best way in which the Universities can serve this important science is by contributing morphological and physiological studies on the various groups of insects. Intensive morphological studies can prove of great help in determining the economic value of insects. The importance of the study of mouth parts has long been recognized in Economic Entomology, and the historical and physiological studies of the insect gut promise valuable results for the use of economic entomologist. The gulf, as a matter of fact, between the academic and applied aspects of Entomology is lesser than the gulf between pure and applied aspects of other sciences. It is therefore desirable that the Universities and research institutions should join hands and march to a common end. There should be only a simple division of labour so that pure Entomology may be tackled at the Universities and applied aspects at the research institutions.

8. Prof. G. Matthai, Dr. Ayyar and a number of speakers felt the necessity of strengthening the teaching of Entomology in the Indian

Universities and the desirability of introducing the subject in our Universities.

9. PRINCIPAL AFZAL HUSSAIN, Lyallpore, moved the following resolution in the full session, seconded by Mr. Mukherji, Calcutta.

'That on account of the growing importance of Entomology fuller facilities for the teaching of Entomology should be provided by the Indian Universities.'

The resolution was carried unanimously.

XXII. BIOLOGICAL CONTROL OF INSECT PESTS.

(Sections of Entomology and Agriculture.)

A joint discussion on 'Biological control of Insect pests' of Sections of Entomology, Zoology and Agriculture was held in the Zoology room (Chemistry Room I, Presidency College, Calcutta) on January 4, 1938, at 1-30 P.M. under the chairmanship of Prof. P. A. Buxton, London.

1. MR. DURGADAS MUKERJI, Calcutta, opened the discussion.

Under Indian conditions only cheap methods of insect control, which do not demand any special skill or knowledge on the part of the farmer, have any such chance of success. Biological control of insect pests satisfies the above conditions. Possibilities of biological control in India: A number of parasites of insect pests occur in this country in different parts, some of these have been profitably employed by American and Australian fruit growers. Before biological control can be attempted a thorough knowledge of parasites is essential.

A Central Biological Control Research Laboratory should be established to collect data, prepare reports and lists of natural enemies of insect pests and to breed such useful insects and distribute them among the cultivators. This organization should also carry out investigations on the principle of biological control, and study the bionomics of parasites and their ecology. Universities specializing in Entomology should institute scholarships for the purpose.

Research work should be conducted to raise disease-resistant varieties and to study the incidence of pests in relation to soil conditions.

2. DR. P. SEN, Calcutta.

The success of biological control of insect pests depends on accurate knowledge of the ecological factors which govern an insect outbreak. Insects may be controlled biologically through their parasites, by some physiological or physico-chemical changes in their environments, or by producing immunity in their hosts. The methods naturally vary in different spheres of applied Entomology. In the domain of medical Entomology biological control of anophelines through fish have given very confusing results. The fish do not appear to be very useful in reducing the anopheline fauna under natural conditions in Bengal. On the other hand by disturbing the nitrogen cycle of the soil and its saline contents a change in the fauna of a breeding place may be brought about and a natural control of a noxious species effected. By controlling the food factors of anophelines through some changes in the flora in their habitat, control of particular species may be effected. Success of control through parasites depends on the determination of the true nature of the parasite to be used. Superficial knowledge is of no use.

For instance *Eurotoma saliciperdæ*, a chalcid long regarded as a parasite of the cecidomyid midge *Rhabdophaga saliciperda* has been found to be nothing more than an inquiline. Several other instances of the same type may be cited.

It is only after careful prolonged researches that biological control can be placed on a sound footing.

3. Mr. S. N. Gupta, Ranchi.

A selective sequence of parasites and predators, which will attack the injurious insect in different stages of its development, so that the component members of this sequence will act in harmony, is essential to effect a successful control. Further the parasite should be capable of outnumbering its host, there should be a higher percentage of females in its progeny, greater number of generations and ability to locate and attack the host. It should be specific where the host has overlapping generations and polyphagus where there are no overlapping of generations or when other factors render the particular stage of the host not easily available.

The importance of predators or parasites as biological control to a certain injurious insect depends on a large number of factors, but where available, predators are more important and effective than parasites.

Artificial (mechanical, physical or chemical) and biological control measures are supplementary to each other rather than incompatible.

4. Dr. Hem Singh Pruthi, New Delhi.

The employment of parasites as a means of combating pests is undoubtedly the ideal method when successful. A large number of entomological workers in different countries are engaged in studying this method, in some cases success has crowned their efforts. In several cases attempts have been made rather prematurely without proper study. The first and foremost requisite is a critical ecological study of the host and parasite in the laboratory and in the field. The influence of different environmental factors on the fecundity and longevity of the pest and parasite must be ascertained, the vital limits established, the rate of development and mortality of the different pre-imaginal stages under different conditions investigated. It would then be possible to ascertain the comparative or differential effects of environmental factors on the host and its parasite and to take advantage of conditions which are favourable to the parasite but unfavourable to the host.

Successful cases of biological control belong to the category of introduced parasites and when optimum environmental requirements have been obtained in the new country. It will be of little use to attempt the introduction of a parasite into a country with a climate very different from that prevailing in the insects' original home. Moreover, before attempting such introduction the potentialities and possibilities of the insect as a pest of any crop plant and its reactions on other useful parasites must be worked out.

It is a fact that no outstanding successful case of biological control can be cited from continental regions, but this should not deter workers in India from exploring the possibilities. There are important physical and climatic factors and extensive mountain and desert belts which act as fairly effective insect barriers dividing India into zones, each with its typical insect fauna, very much like the islands or insular regions where successes by biological control have been obtained.

With indigenous parasites, in spite of mass-multiplication and liberation, little success has been achieved. It is argued that although the population of an indigenous parasite in nature may be low the total number in a locality is far too high to be appreciably affected even by apparently large subsequent liberations. This is not always true. There

are cases in which an adverse season seriously reduces the parasite population without affecting the host to the same extent. Therefore the parasites come into prominence very late in the seasonal activity of the host in nature. The numbers of a parasite in the beginning of the competition cycle may materially help the parasite to get a good start, and mass collection of the parasite during its abundance and helping it to pass unfavourable season either under artificial optimum conditions or at a temperature low enough to arrest its development without impairing viability, may help.

5. P. N. Krishna Ayyar, Coimbatore.

Some aspects of Biological Control.

Possibilities of biological control particularly in respect of an indigenous insect like *Pemphers affinis* Frh, the cotton stem weevil of South India. I have been actually engaged in exploring the possibilities of the biological control of this weevil borer for the last two years and I wish to narrate my experience and methods of tackling the problem so as to prove that this method, though based on sound principles, is not so easy as is often represented. It requires great care and technical skill. There are many factors to be studied which are unknown.—We have to know all about the pest and parasites and their ecological complex of factors. Concerning the pest, it has to be ascertained whether the pest is an introduced one or indigenous for the methods differ in the two cases. As most successful cases of biological control are found in cases of imported pests, there arises the question whether native pests can be successfully tackled by this method. As Thompson says this method is universally applicable under favourable conditions. An instance to prove this may be taken from leap . . . . beetle of coconut in Fiji. In the case of a native insect the same principles as those of an introduced pest hold good. Only instead of finding the original home of the imported pest we have to find out the original habitat of the native pest. From its original habitat the natural enemies may be brought and introduced in cultivated areas. My search has proved that in the case of this weevil its original habitat is not probably cotton but some wild plant. I have also obtained a few parasites which are absent in cultivated areas. It remains to be seen whether these parasites will establish and accommodate themselves in cotton fields.

6. S. Pradhan, Lucknow.

In Biological control effort is generally made to find out some predator or parasite which directly and immediately attacks the insect which it is desired to control. In this effort a lot of energy is spent, and when a suitable predator or parasite is not found locally, effort is made (often with failure) to transport a suitable controlling agent from other parts of the world. May I put forward my belief that much success may be obtained if energy is concentrated on an intensive study of local Biology specially the relation of one living being to another in a certain area. This study is sure to reveal what may be called the Local Balance Cycles in which one living being is dependent on the other. After such balance cycles are ascertained it will be easy to spot out the weakest point in the cycle whence it is easiest to disturb the balance and thus to control a particular insect pest.

7. Dr. T. V. R. Ayyar, Madras.

I referred to my paper on this subject read at the Benares Session of the Congress in 1925. Having no time to speak on all the salient points I referred to the following as the most important points in this matter.

(i) A thorough and systematic and bionomic study and survey of the entomophagous insects of India so as to know what are the forms we have in India at present.

(ii) The importance of various kinds of parasites and complexes connected with insect pests so as to eliminate the injurious from biological forms. This required a good deal of artificial breeding and careful release of the beneficial forms.

A slide of the *Nephantis* caterpillar complex was exhibited to show this difficult aspect of parasitism.

I then referred to same work in India in connection with the cotton boll worm the coccid *Ioryx* recently introduced in S. India and then on the work done in Madras on the coconut caterpillar *Nephantis*. I concluded by saying that, though the method is really very tempting and easy if *successful* the method is not so very easy as many of us wish to think it to be. As I said before a good deal of careful work has to be done. I also exhibited a slide of the efficient prickly pear cochineal which was used in S. India extensively with great success. I concluded by warning entomologists and agriculturists that the method though very desirable and efficient is not such an easy method to accomplish.

8. Prof. G. H. Carpentor, Oxford, remarked that how in Africa in case of Tsetse flies by changing the environmental conditions the pests can be brought into a check.

XXIII. ANIMALS AND THEIR DISEASES IN RELATION TO MAN.

(Sections of Medical Research, Veterinary Research, and Physiology.)

Professor Sir Frederick Hobday, London.

In India as well as in England there are certain diseases of animals and man which are of mutual interest to the medical man and the veterinarian, whether on account of their analogies or their differences, or by reason of the fact that they are contagious from animals to man, or *vice versa*; and it is not wise for either branch of medicine, nor yet for our mutual patients, for us to work in watertight compartments. It is better from every point of view that we work in collaboration. Some diseases, such as cancer, tuberculosis, anthrax, and tetanus we attack respectively in somewhat different ways; whilst others, such as glanders, rabies, foot-and-mouth disease, mange, and ringworm, can only be effectively dealt with by definite collaboration between medical men and veterinarians. There are others in which as yet there has been no effectual attempt at collaboration. Such ailments as common catarrh and the influenzas can be dealt with to mutual advantage from a comparative aspect, as can more complicated ailments such as Hodgkin's disease, and such common ailments as rheumatism and fibrositis. An exchange of ideas as to the symptoms, methods of spread, etc. in our various patients is of undoubted help towards elucidation. In veterinary medicine, equally with the human side, the study of collateral branches of science, such as entomology or parasitology, is of material help, and in teaching colleges, as in hospitals, a knowledge of the life-histories of the various flies and insects which act as carriers or transmitters of parasites is as essential to the veterinary student as to his medical confrère. In the clinical world, too, we have many points in common, for

our animal patients suffer from gastritis, indigestion, colic, internal parasites, colitis, swallowing of foreign bodies, and various forms of pneumonia and heart disease, to the same extent as human patients do, and our veterinary treatments are similar in principle to those in human practice. The veterinarian has, however, a greater variety of internal arrangements to deal with, having to take into account whether his patient is herbivorous or carnivorous ; or whether, as is the case in man, it will eat anything and everything which it has an opportunity of eating. Some of our patients have only one stomach, whereas others have four—while the camel stands by itself in having three—so that their respective digestive processes vary very much in detail.

I feel sure that when a number of these diseases, both epidemic and otherwise, are studied from this point of view, we shall be able to advance more quickly and find many new ideas and theories, which up to the present have not been thought of. It is not only in Great Britain that diseases may be studied in this way, for those who live in the tropics have also plenty of opportunity for following up comparative medicine. The different effects which various foods have on man and animals also form a good illustration. For example, the flour of certain forms of Indian pea has a nerve-paralyzing effect not only on the natives continually fed on it but also on horses, producing laryngeal paralysis which causes dyspnœa on the slightest exertion. Again in entomology, in the study of the life-histories of the various flies and insects which act as carriers and transmitters of disease-germs or blood-parasites, the knowledge acquired by collaboration is of mutual benefit in epidemiology, not only in the diseases transmitted from animal to animal but in those transmitted from animal to man. In the short time now at my disposal I shall confine myself to a selection of a few diseases concerned with Public Health, which are communicable from animals to man, in the treatment of which the practitioner of human medicine can obtain material help from collaboration with his veterinary confrère.

Glanders.

This is primarily a disease of the hors etribe, and affects horses, asses, and mules. Its cause—the *Bacillus mallei*—is an extremely dangerous organism to work with in the laboratory. The disease is one which is most commonly met with amongst stable-workers and those who come in contact with horses, and a man can be readily infected by the discharge from the nostrils of an infected horse or even by handling the brushes, sponges, or stable-cloths, which have been in contact with a glandered horse. In the South African war it accounted for the deaths of many thousands of our Army horses, and indeed in all wars it has been the bugbear for which the Army veterinary officer must always be on the look-out.

It is so insidious that, until it has been present in the system for a certain length of time, its presence may remain unsuspected. Modern veterinary science has now, however, at its command a method by which the presence of glanders can be ascertained, for by the introduction of a few drops of mallein (a special preparation made from the *Bacillus mallei* itself) the skilled veterinarian can make a diagnosis with certainty within forty-eight hours, even if the animal is infected only in the slightest degree. During the Great War, by means of this test, applied by the officers of the Royal Army Veterinary Corps, glanders was entirely eradicated from the horses and mules of the British Army, and it has been applied so successfully in Great Britain that at the present time the disease has absolutely ceased to exist. This means that not only has it been eliminated from the list of ailments which the veterinary surgeon is called upon to diagnose, but it has also been eliminated from the list of diseases in man ; and in an island country like Great Britain so long as the present regulations of the Veterinary Department of the

Ministry of Agriculture and Fisheries are kept in operation the country will be free from this terrible affection. In India I understand that it is still a problem to be dealt with, but of this I hope to hear something in the discussion.

Rabies.

This disease has not been met with in man in England for more than thirty years, and it can never appear again as an epidemic in this country, so long as control is kept upon the importation of animals of the dog and cat tribe. The primary cause of rabies in man is the contact of an abraded surface of the body with the saliva of a rabid animal, and whether the infected animal is a horse, a sheep, or any other animal, it has always had its primary origin in a rabid dog and cat. The Muzzling Order succeeded in eradicating the disease from Great Britain, and it then remained for the Veterinary Advisers to the Ministry of Agriculture and Fisheries to take steps to see that it was not reintroduced into the country. This explains the present quarantine regulations imposed on all dogs and cats admitted from countries where rabies exists. The absence of the disease is further proof of the value of the collaboration between the forces of the veterinarian and the medical man in the cause of Public Health. In India you are much more heavily handicapped than we are in England, especially on account of the numbers of pariah dogs, over which, I understand, it is difficult to obtain control.

Anthrax.

This condition is, I understand, even more prevalent in India than in England, and is particularly met with in cattle, horses, sheep and pigs; the dog, cat and fowl possess a comparatively high power of resistance to the infection. It is a disease which is always serious and, in animals, invariably results in death. In cattle, especially, death is very sudden, and in Great Britain the Government has imposed laws and regulations which provide that the body must be cremated as near as possible to the place where the animal died. It is forbidden, too, in any way to cut the carcase, for on many occasions those making, or assisting at, the post-mortem have become infected and have died in consequence. In cities and towns in England where wool from foreign countries is handled, disinfection is compulsorily adopted, with satisfactory results. If this practice could also be efficiently adopted in the case of hides, bone manure and other animal products, before they are imported into this country, the number of deaths from anthrax in man and animal would diminish considerably. Cotton, linseed, and other cattle-food cakes come into the same category. Once eradicate anthrax from the animal and animal products and eradication from man would automatically follow. Anthrax is primarily a disease for the Veterinary Surgeon, as it always originates from some product obtained or used by an animal.

Foot-and-mouth Disease.

This disease has at times, in the daily Press, provoked a good deal of unwarranted criticism directed against the Veterinary Advisers to the Ministry of Agriculture and Fisheries, yet there is no doubt that, in England, they have adhered to the correct policy (that of 'Stamping out'). We have much upon which to congratulate ourselves when we compare our position with that of other European countries. The cost of Holland, France, Belgium, Denmark, and Germany, amounts to tremendous sums each year, and these countries never get any further forward in the matter, having the disease always endemic. The fact that we are an island is of incalculable value to our Ministry of Agriculture, whose responsibility it is to frame the laws which control the importation of animals from any country from which infection may be brought.

The following statistical table, showing the respective numbers of outbreaks in other European countries during 1934, is convincing evidence :—

Month	Great Britain	France	Germany	Holland	Belgium
January	1	1,074	113	579	329
February	—	652	80	214	168
March	—	613	73	105	102
April	—	287	110	59	81
May	1	135	48	51	40
June	—	146	56	132	36
July	—	98	27	459	19
August	3	92	40	1,391	15
September ..	4	21	19	3,120	20
October	24	15	14	2,880	9
November ..	28	3	16	48	1,173
December ..	18	28	32	230	20

The public should think what a terrible disaster it would mean to a small confined country like England if the disease were allowed to spread, with the fact that milk from cattle affected with foot-and-mouth disease must not on any account be consumed by children or invalids, or be given to goats, pigs, or any other animal.

In India I understand it is always more or less with you but in a much milder form than we get it in Europe and that conditions necessitate curative and prophylactic treatment.

Tuberculosis.

This is pre-eminently a disease which illustrates the value of collaboration between the medical man and the veterinarian in the cause of Public Health. No variety of domesticated animal is immune to tuberculosis, although some are more susceptible than others. The goat, the sheep, and the horse are probably the least affected, but even in these it is only a question of degree, and there is no actual immunity when they are placed under conditions favourable for infection. Birds, especially poultry, are frequently affected, and whenever the disease appears amongst them the whole flock may have to be destroyed before it is eradicated.

It is a disease which the practising veterinarian meets with most commonly in cattle, and there are about a million tuberculous cattle in Great Britain at the present time. These are not all dairy cattle, but it is in these that the danger lies for man, as it is well known that at least 40%—and, in some districts, 60%—of them are affected.

At one of the National Milk Conferences Dr. Stanley Griffith, in a paper on 'Bovine tuberculosis and its relation to man', gave some statistics which went to prove more than ever the necessity for medical practitioners and veterinarians to pull together. In an investigation of 1,200 cases of tuberculosis he had found that 87·5% of infections with tuberculosis of the cervical glands, in children up to the age of 5, were bovine; and similarly 61·3% of those between 5 and 10 years; 37·9% of those between 10 and 16 years; and 25% of those of 16 years and over. Of 476 cases of bone-and-joint tuberculosis 28·7% of those under 5 years were of bovine origin; 23·1% of those between 5 and 10 years; 9·5% of those between 10 and 16 years; and 6·4% of those of 16 years and over. Of 126 cases of lupus: 69% of those under 5 years; 42·5% of those between 5 and 10 years; 60% of those between 10 and 16 years; and 17·6% of those of 16 years and over were of bovine origin. The same medical scientist estimates that tuberculosis contracted through the consumption of cow's milk causes approximately 3,000 deaths in young children every year. As all these infections are caused by drinking the milk of cows suffering from tuberculosis of the milk glands, it is hoped

that the new regulations of the Live Stock Industry Bill which came into active operation in January 1937 will, so far as Great Britain is concerned, have the effect of eliminating, in a great measure, the chances of infection from the cow to man.

Although only about 1% of dairy cattle are affected in the udder, and until the infection has reached this organ the milk does not necessarily contain tubercle bacilli, an infected cow is always a possible source of danger, for one can never tell exactly when the udder tissues will become infected and the milk a source of definite and terrible danger to the children to whom it is given.

Pasteurization, undoubtedly, offers some safeguard, but it is generally admitted that some of the valuable properties which raw milk possesses are lost during this process, and there can be no doubt that the best solution of the prevention of infection lies in the endeavour to obtain an absence of the tubercle bacilli at the source of supply—i.e. the dairy herd. That this can be accomplished, if pecuniary and other necessary adjuncts are available, has been proved by actual experiments, and America has been especially go-ahead in her endeavours to form accredited herds. In that country whole districts have been cleared, and the most stringent laws are enforced in order to prevent reinfection by the entrance of tuberculous beasts into these areas.

In Great Britain progress in this direction has been slow; as the British public, although not unmindful of the advantages of tuberculosis-free milk, is not willing, as a body, to pay an extra price for this guarantee. Dairymen who have gone to the expense and trouble of clearing their herds have not received the encouragement they deserve either from the general public or from the hospitals and medical practitioners. These last, in particular, might do a very great deal more than they are doing to assist in educating the housewives and mothers of young children as to the dangers of tuberculous milk, by urging upon them the necessity for demanding a clean milk supply, i.e. one from tuberculin-tested cows.

This matter is now being seriously taken in hand, and a Veterinary State Service is being formed, with a staff of whole-time men whose duties consist mainly of inspection of dairy cattle with a view to the formation of tuberculosis-free herds. A clinical inspection is made of the udders periodically, usually four times a year, and for the owner who wishes to ensure that his herd is completely free from tuberculosis the cows are tested with tuberculin—of which we now have a synthetic variety—and by the intradermal method which forms a much more delicate test than the former subcutaneous method. We have reason to hope that this newly formed Veterinary State Service is thoroughly justifying its existence and that it will prove of benefit not only to human beings, by getting rid of a source of tuberculous milk, but also to the dairyman and the agriculturist, by weeding out from his herds tuberculous cattle whose presence is always a source of danger. It is a common observation that the herds from which tuberculosis has been eliminated are much more resistant to other ailments—the services of the veterinary surgeon being less in demand than when this disease existed.

Mange.

Mange of the horse is now dealt with in all parts of Great Britain and is compulsorily notifiable under a Mange Order issued from the Ministry of Agriculture and Fisheries. Its spread has been effectually checked, and although it is not yet completely eradicated, the number of cases in the horse is now extraordinarily small. It is, however, to the domestic pets, especially the dog and cat that attention should be drawn, for it is quite an easy matter for a pet dog to transmit the parasite of mange from itself to its owner. An itchy dog should, therefore, always be regarded with suspicion, and the pernicious habit of allowing a dog to sleep in bed with a human being should be emphatically discouraged.

A dog with mange, especially in hot weather, or when its body becomes heated by lying in front of the fire (or sleeping on an eiderdown or blanket), will be continually scratching, especially in the region of the armpits and under the thighs, where the body is hot and the hair is thin. If no treatment is adopted, the dog will break out in sores, the hair will fall off, and the animal will presently smell very offensively and become covered with scabs. If allowed to come into contact with any part of the human body for more than a few minutes, it is quite an easy matter for the parasite to transfer itself to its human host, and it may remain for a considerable number of days, or even weeks, until it has finished its life-history. During this time it will give rise to a great deal of irritation and discomfort, which could easily have been prevented had the owner of the dog sought veterinary advice.

There are numbers of other diseases in which it is of value to the Public Health service that in the fight for their eradication the human physician and the veterinarian should collaborate, for the patients of each are equally attacked. Cancer may be taken as a type. This dreaded disease is recognized in such veterinary patients as horses, cattle, dogs, cats, and even fish, and many of the theories which research workers form, if their observations are concentrated on man alone, may at once be seen to be erroneous upon comparing notes with veterinary pathologists, whose lives bring them in contact with the comparative aspect. In foreign countries this has been for a long time recognized, and their governments have granted liberal funds for research into the problems of animal diseases and their relation to Public Health, finding it a paying proposition, even if considered only from the economic standpoint. Great Britain has been behindhand in this respect, but during the past few years with the establishment of the Animal Research Institute connected with the Royal Veterinary College, at Camden Town, and of the Institute of Animal Pathology at Cambridge, together with the creation of University Veterinary degrees and a Post-Graduate Diploma of Veterinary State Medicine, there is a good prospect that, long before another decade has passed the Government organization of Veterinary Officers of Health will have as important a place in Public Health as is accorded to the graduates of the human branch of state medicine.

My list of those diseases which furnish valuable instruction in the epidemiology of animals and man is by no means complete, but I must in conclusion just allude to one other—namely contagious abortion of cattle—which gives rise to Undulant Fever of man. That cases of transmission from the cow do occur is generally admitted, but not as frequently as might be expected when one considers the great prevalence of this disease in milking cattle. In connection with milk too as a food product one must not forget to draw attention to its danger as a carrier of disease in such diseases as scarlet fever and diphtheria of man.

In conclusion I think that you will agree that I have introduced sufficient framework in the brief time at my disposal to illustrate the importance of consideration of the inter-relationship between the diseases of animals and man.

G. S. Thapar, Lucknow.

Animals have long been associated with man and their domestication has naturally led to the transmission of their diseases to man. The various diseases thus transmitted may be caused by bacteria, protozoa, worms and insects. The speaker proposes to deal with *only* those diseases that are due to worms (helminths) and thus the responsibility of the domestic animals in the spread of helminthic infections in man is indicated.

For convenience, the subject is considered under three categories thus:—

1. The helminths which are of common occurrence as adults, both in animals and in man.

2. The helminths that occur as adults in man, but as larvæ in animals.
3. The helminths that occur as adults in animals but as larvæ in man. Such cases are only accidental.

Instances are given under each and it has been shown that animals are important in the transmission of helminthic infections in man. The mode of their transmission is also discussed and an emphasis is laid on the rôle of domesticated animals and pets and also on the reservoir hosts in this connection.

The methods of control of the helminthic infections are discussed and the difficulties in the adequate control of helminthic infections in animals are pointed out. It is also shown how a helminthologist is necessary in the discovery and subsequent eradication of the diseases of helminthic origin. The value of meat inspection, which is so inadequate at present in India, is also emphasized.

In view of these facts, it is suggested that there should be greater co-operation between the medical and the veterinary investigators and between both these and the zoologists. The latter would, as is apparent from the work in the past, be able to help them in the solution of many of the intricate problems associated with the helminthic infections of man and domestic animals. This is indicated further by the organization of the Institute of Agricultural Parasitology under the direction of Professor R. T. Leiper at the London School of Tropical Medicine.

XXIV. RIVER PHYSICS IN INDIA.

(Sections of Mathematics and Physics, Geology, Geography and Geodesy, and Agriculture, in co-operation with the National Institute of Sciences of India, and the Indian Physical Society.)

1. PROF. M. N. SAHA presided and opened the discussion.

2. MR. D. N. WADIA, Calcutta.

Changes in the courses of Indian rivers during the latest geological epoch.

Few changes in the physical geography of India during historic times and in the Sub-Recent geological age have been so well proved as changes in the river-systems of Northern India. These changes in the number, volume and direction of the chief drainage-lines—in some instances amounting to a complete reversal of the direction of flow of a principal river—can be classified :—

I. Prehistoric—the change of a great north-west-flowing river of early Pleistocene time from Assam to Punjab and Sind, which carried the combined waters of the Brahmaputra, Ganges and Indus, to the present hydrographic system of Northern India (*Indobrahm*).

II. Changes during historic times—

A. In Punjab and Sind :—

(1) The *Sarasvati river* of Vedic times, the 6th river of the Punjab, becoming the Jumna tributary of the Ganges in the days of Manu.

(2) The well-known lost river of the Punjab (*Hakra*) over 600 miles long, which up to the 10th Century flowed from

Himalaya to the Rann of Cutch (then an inland sea) through the *Eastern Nara*—the Hakra was probably a deserted bed of the Sutlej, which up to the 13th Century flowed independently of the Indus, without joining the Beas.

(3) The migration of the channels of the Beas, Sutlej and Chenab through the Punjab plains.

(4) The obliteration of the Sind Gulf by southward encroachment of the Indus delta, building the plains of Sind by the oscillation of the Lower Indus.

(5) The present Soan valley, a mis-fit, the sole remaining portion of the Indobrahm.

B. In Bengal :—

(1) The rapid southward extension of the Gangetic delta during the last 5,000 years from its head in the Rajmahal hills and Sylhet lagoons.

(2) The diversion of the Brahmaputra to the east of Madhupur and its later deflection again to the west.

(3) The oscillation of the Ganges and Brahmaputra channels during the last few centuries and the easterly growth of the delta.

(4) The deflection of the Teesta from its confluence with the Ganges to the Brahmaputra.

3. DR. SUNDER LAL HORA, Calcutta.

Changes in the drainage of India, as evidenced by the distribution of freshwater fishes.

The author directs attention to the various modes of dispersal of freshwater fishes and points out that they constitute an important group for the elucidation of palaeohydrographical problems. The occurrence of the Dipnoan and Ganoid fishes in the Upper Gondwana Beds of Kota-Maleri shows the position of the main river of the Mesozoic period. From the past and present geographical range of these ancient fishes some idea is given of the probable drainage pattern of India of those times.

The greater part of India proper of the Eocene period is now covered by the Deccan trap which has obliterated the channels forming the drainage of India during that age. Some evidence of the location of the main drainage channels is, however, furnished by the fish-remains found in the infra-trappean beds at Dongargaon, Dhamni and Phisdura and the inter-trappean beds at Takli, Pahadsingha, Deothah, Kheri and Kateru. From the situation of these beds it is inferred that the main drainage channels of the Eocene period were, more or less, in the same position as those of the Mesozoic epoch. From the nature of the fish-fauna it is clear that the sea was not far removed from the trappean beds of the Central Provinces. Attention is also directed to the fact that a predominantly Ganoid fauna of the infra-trappean period was, more or less, replaced by the modern bony fishes during the inter-trappean periods.

As practically all the principal genera of bony fishes had already appeared during the Tertiary, further changes in the drainage of India are adduced from the geographical distribution of the modern fishes. The orogenic movements that gave birth to the Himalayan chain of mountains produced a succession of changes in the drainage pattern of India. The distribution of fishes shows that for a considerable time the longitudinal basin formed as a foredeep at the base of the Himalayas served as the main drainage channel. This channel was discovered by Pascoe and Pilgrim simultaneously and designated as 'Indobrahm' or 'Siwalik

River' respectively. This river is believed to have flowed from east to west and carried the combined waters of the Brahmaputra, the Ganges and the Indus. In the author's opinion its headwaters were probably in Southern China, and in support of this contention several instances are cited from the distribution of allied genera of fishes.

Certain localized orogenic movements resulted in the dismemberment of the 'Indobrahm' into at least three drainage systems, the Brahmaputra, the Ganges and the Indus. In this process the once continuous fish-fauna became segregated into definite regions. A detailed study of some of the elements of this fauna shows that the Brahmaputra portion was the first to be separated and that the Ganges and the Indus flowed together as a combined river for a considerable time afterwards. The fish-fauna of the Ganges and the Indus are almost identical and this would indicate that the two rivers probably became separated, geologically speaking, not very long ago. Attention is here directed to the fact that the Jumna river, a tributary of the Ganges, was a tributary of the Sutlej within historic times.

One remarkable fact of distribution of Indian freshwater fishes is the close similarity between the fauna of the Eastern Himalayas and that of the hills of the Peninsula in the extreme south. This is explained in terms of the geological changes that may have occurred at the time of separation of the Brahmaputra from the 'Indobrahm' of the Tertiary period.

The probable mode of evolution of the present-day drainage pattern of the Himalayas is discussed and evidence is adduced to show that it has developed from a consequent drainage, e.g. rivers draining north and south of the crest.

The fish-fauna of India is probably derived from that of Southern China and Indo-China and its transference towards the west and south appears to have been facilitated by longitudinal valleys, river-captures, etc. In South-Eastern Asia the southern and western portions appear to have been sinking and this has made the north fauna migrate towards south and west. The present-day distribution of fishes strongly supports such a hypothesis. The eastward flowing rivers of the Peninsula probably assumed their present direction after the rise of the Western Ghats; their antiquity is apparent from their broad valleys.

Another fact of fish distribution, to which reference is made, is that of the large carps of India and several other species which are not found south of the Kistna river. From this certain inferences are drawn regarding the probable drainage of the Peninsula.

4. Mr. C. C. Inglis, Poona.

The use of models for elucidating flow problems based on experience gained in carrying out model experiments at the Hydrodynamic Research Station, Poona.

Hitherto it has been customary to talk of hydraulic model experiments in general terms, as though only one type existed; and then, either to accept the results as being directly applicable to the prototype or else as only a guide, or even as giving results of doubtful value.

As recently as December, 1935, Herbert D. Vogel, at that time Director of the U.S. Waterways Experimental Station at Vicksburg, after asking information from 50 laboratories or individuals engaged in hydraulic research, stated: 'With a few notable exceptions, the replies contributed scarcely any information directly pertinent to the subject.'

In this Paper the 8 main types of models are described with examples showing why some types present little difficulty and give results suitable for immediate application whereas other types, especially those relating to alluvial rivers, present very great practical difficulties.

Types of models :

I. Models which are geometrically similar in shape to the prototype and give geometrically similar results.
II. Models which are geometrically similar in shape ; but do not give geometrically similar results.
III. Regime models, in which conditions of flow are maintained constant, with complete freedom as regards silting and scouring.
IV. Combined erodible channel and rigid models.
V. Rigid and semi-rigid vertically exaggerated models in which conditions are imposed, e.g. tidal models.
VI. Models with mobile protection—falling aprons, spurs, protection round piers, etc.
VII. Meandering river models.
VIII. Combined rigid, mobile and meandering river models.

Geometrically similar models in which parallel flow or free vortex flow are established give geometrically similar results provided they are not too small to make it possible to reproduce the boundary conditions of the prototype. In other cases similarity is not attained.

Channels may be divided into two classes :

(*a*) Channels flowing within rigid boundaries;
(*b*) Channels flowing in incoherent alluvium.

In the former, flow is under flumed conditions and a heavy supercharge of silt can be carried provided the slope is sufficiently steep. In the other type, flow is 'natural', adjustments to changing conditions being brought about by scouring and silting. Lindley, in his Paper on 'Regime channels', Punjab Engineering Congress, 1919, put forward the original theory that 'the dimensions, width, depth and gradient of a channel to carry a given supply loaded with a given silt charge were all fixed by nature' and some ten years later Gerald Lacey, in his paper on 'Stable channels in alluvium', *Procs. of Inst. C.E.*, Vol. 229 (1929-30), produced a series of formulæ which fixed gradient and shape of regime channels. These formulæ have gradually been winning acceptance all over the world.

According to Lacey, $P = 2{\cdot}67\sqrt{Q}$, a formula which is now generally accepted, from which it follows that $P/R = 7{\cdot}12\ V$, where P = wetted perimeter; Q = discharge, R = hydraulic mean depth, and V = velocity. This is the Lacey 'shape formula'. According to Lacey's 'initial regime formula' $V = 1{\cdot}17\sqrt{fR}$, where f is the silt factor, which is proportional to V^2/gR, the Froude number. So, on the assumption that a regime channel approximates to a semi-ellipse, with the semi-circle as the limiting shape, $Q_{\text{lim}} = 1{\cdot}82/f^2$. Actually, however, for reasons explained in the paper, $Q = 3{\cdot}2/R^2$ is the minimum discharge with which it is safe to work.

1. From the Lacey formula and from Nikuradsa's work on roughened pipes it follows that the finer the silt, the larger the discharge required in the model.

2. There is a natural regime silt charge, which varies with the discharge and silt grade and there is a minimum velocity for each silt, below which the regime silt charge cannot be carried.

3. For the same grade of silt the lower the discharge the more sensitive is the model to a super-charge of silt.

The regime conception must form the basis of all accurate model work dealing with movement of silt, and its division between off-takes.

4. Experiments with *combined erodible channels and rigid models* present difficulties because the flow formula is different in the two parts and hence a model which is identical in plan in model and prototype cannot give similar results. In many cases this can be overcome by

fitting. Part of the difficulty is due to the fact that though vertical exaggeration has been adopted as common practice in model work, lateral exaggeration, which is also natural has, so far as the author can determine, been overlooked.

5. One of the best known types of models is the 'tidal model', which falls under the semi-rigid model type. In this, conditions are imposed, the sides, and in many cases a considerable part of the bed, being held against scour. Such models give valuable results provided they are correctly designed; but the fact that conditions are imposed must not be overlooked. Rigid models are used in America for determining the effect of 'cut offs' on upstream water levels and they give valuable information as to the immediate effect on water levels upstream, but that is all. Models with mobile protection, e.g. falling aprons, pier protection, etc. give geometrically similar results of great value.

6. Combined rigid, mobile and meandering river models present many difficulties, because the laws governing each of the three types, here combined, are different. To solve such problems, experiments to determine the scale effect of various factors have to be carried out in separate models and the results of these applied in the large, full length model. Even in a very large model, though accurate results for full supply discharge can be obtained, with low supplies difficulties arise in reproducing scour in the model.

7. The main fact which follows from this paper is the importance of large models; and at Poona the discharge now preferred ranges between 6 cusecs and 15 cusecs in each model, but may be as much as 30 cusecs in a single model.

Although in general the larger the model the better the results, it must be remembered that doubling the size of a model quadruples the area, the discharge and the labour involved; and increases the time factor to approximately 1·6 times.

8. The general conclusion is that in competent hands, a very wide range of experiments with large models gives results of high qualitative accuracy and may also give quantitative accuracy; but in general the data available for river models is meagre and though the gaps in data can be filled to a large extent from field experience, so that a model can be made to reproduce what has previously occurred in the prototype under known conditions of discharge and silt charge, the problem which generally has to be tackled is what will happen if nothing is done or what should be done to prevent further damage.

The answer to this depends almost entirely on a capacity to foresee probabilities and possibilities and an intimate knowledge of the engineering side of the problem under consideration. Model experiments are, in fact, a very valuable aid in the solution of practical problems but success depends mainly on engineering skill, which they cannot replace.

5. Mr. Gerald Lacey, Roorkee.

The author, dealing first with his subject historically, and with that branch of river physics which may be denoted the study of the behaviour of Indian rivers by the engineering profession, ascribes the origin of the science to the construction of the first major canals in northern India and Madras nearly a century ago. The construction of the canal headworks presented problems in the flow of water both in boulder and in sandy alluvium; the canals, which transported alluvium withdrawn from the rivers, drew attention, from their instability, to the phenomena of silt and scour.

The growth of communications and the construction of road and railway bridges founded on wells sunk in an alluvial bed enforced the investigation of allied problems. The author dates the modern study of river training and control from the publication of Sir Francis Spring's classic paper in 1903.

Early difficulties on canals, particularly in respect of the hydraulic gradient, were diminished by the successive publication of the flow formulas of Bazin and of Kutter: it was not however until Kennedy produced, in 1895, his empirical equation correlating the depth of a channel with the critical regime mean velocity that the foundation of alluvial studies was firmly laid.

Reference is made to the invaluable model experiments of Osborne Reynolds in 1888, and to the slow realization of their full significance.

The author draws particular attention to the phenomenon of exaggeration in the vertical scale of models. The necessity for this exaggeration, so frequently ascribed by the laboratory worker to the need for silt movement and of avoiding laminar viscous flow, arises from a feature common to all channels large and small. He refers to the invaluable data now made available from canal systems in India, and the manner in which such data fills the gap between the laboratory worker and the river engineer.

Reviewing modern developments the author shows how the earlier equation of Kennedy connecting the mean velocity and the vertical depth

$$V = mD^{\cdot 64}$$

can be replaced by the author's formula

$$V = kR^{\cdot 50}$$

involving the hydraulic mean depth. He shows further that the hydraulic mean depth and the slope are correlated by the equation

$$R^{\cdot 50}S = k'$$

From the latter two equations he demonstrates, by recourse to the theory of models, that the wetted perimeter and the discharge are correlated by the simple expression

$$P \propto Q^{\frac{1}{2}}$$

a relationship that has been amply confirmed by statistical work in India.

The author quotes the equation derived by him

$$V = 16\ R^{\frac{2}{3}}S^{\frac{1}{3}}$$

applicable to flood conditions in alluvial streams, in which the rugosity is implicit in the depth and slope adopted.

The author shows how it is possible by the use of his equations to determine the scales for models with tidal or uniform flow, and indicates how the problem of the railway engineer, both in respect of scour and of waterway may be solved.

The author comments on the statement that in a regime channel the dimensions are uniquely determined by the discharge and silt grade, and emphasises how in Nature one of the variables may prove a constant and a dominating factor. He applies his equations to a study of flow in the boulder regions of rivers, and in the true alluvial plain, defines 'tortuosity' and 'meandering,' and discusses 'silt sorting' and 'attrition' as contributory factors to the known characteristics of rivers in their course from the foot hills to the sea.

The author holds, despite the complexity of flow in alluvial rivers, that ultimate knowledge of river physics must be based on normal or regime equations of the type formulated.

In view of the fact that in alluvial channels the bed is non-rigid, and moving slowly forward, the author deprecates the application of formulæ derived from pipes, in which the velocity distribution is patently of a very different order. As the author conceives the problem the normal cross section in alluvium closely approximates to a semi-

ellipse of which the water surface coincides with the major axis, the isotachs being confocal. The method of mathematical attack would be similar to that of Prandtl, the formulas should be different, and not far removed from those put forward by the author.

6. Mr. Kanwar Sain, Lahore.

The effects of the construction of weirs and weir-controlled canals on the regimes of the Punjab rivers.

This paper deals with the Punjab rivers only. 'Punjab' is a Persian compound word, composed of 'Punj' and 'Ab', meaning 'five' and 'waters' respectively. The first Aryan settlers knew this part of India as the land of the seven rivers (*Sapta* Sindhavas), consisting of the Saraswati, the Sutlej, the Beas, the Ravi, the Chenab, the Jhelum and the Indus. Saraswati is now a small river and discussion is confined to the other six rivers only.

An attempt has been made in the paper to summarize the results of an examination of the changes that have occurred in the regimes of the above rivers as a result of the construction of weirs and weir-controlled canals.

The examination was carefully made by a committee of two Superintending Engineers, one from the Punjab and the other from the Bombay Presidency, and consisted of a critical analysis of about 9,67,000 gauge readings actually observed and recorded since 1861.

Perhaps no other set of rivers in any other province or country provides such a wealth of information on this aspect of the 'River Physics'. This will be amply borne out by the fact that no less than 13 weirs have been built on the six Punjab rivers and that the total withdrawals from these rivers by weir-controlled canals exceed 1,50,000 cusecs.

The first effects that may be anticipated from the construction of a weir are:—

(*a*) the flattening of the slope of the river upstream, and
(*b*) lowering of the level of the water surface downstream, both due to the reduction in the amount of water passing below the weir and also to a degradation of regime levels.

The examination of levels over long periods, however, shows that after the construction of a weir on an alluvial river, the upstream slope tends to recover, and over a sufficient term of years will recover its former value; also that irrespective of reduction of discharge the levels downstream of a weir will, in a period which may extend to 20 or 30 years, recover and even rise above their former value, while specific levels show a greater rise.

It is also shown that the withdrawals of water from one river of an alluvial system produce sympathetic changes in the regime of another river joining it.

7. Rai Bahadur A. N. Khosla, Jhang.

Design of weirs on permeable foundations.

8. Dr. N. K. Bose, Lahore.

River physics laboratories of Europe and America.

Of recent years conviction has been gaining ground among hydraulic research workers that there is a physics of river flow and as such it is possible to study river movements and the changes in the course of a river from scale models in a laboratory. Though the science of River

Physics has not attained to that stage of development as has been reached by the science of Nuclear Physics or any other branches of Physics, yet since the days of M. Fargue, Osborne Reynolds and Vernon-Hercourt the progress of this branch of Physics has been very rapid. The experiments of Prof. Gibson in England, of Engel, Winkel, Krey and Rehbock in Germany and of Freeman in America have proved conclusively that not only can scale models, properly conducted, give valuable indications for the training of a river, quantitative information can also be obtained from such experiments. In his tidal model of the river Severn Prof. Gibson has been able to reproduce the conditions of the river in 1927 starting with the river in 1848. Prof. Krey in his Elb model and Prof. Rehbock in the Rhine model have been able to get very good quantitative agreement between the model and the prototype. In the U. S. Waterways Experimental Station at Vicksburg Vogel has been able to reproduce various conditions of the river Mississippi in a number of models. In this paper it is proposed to deal with the various methods applied by different workers in developing their river models and also the amount of success they have attained in them.

9. Mr. S. C. Majumdar, Calcutta.

River problems in Bengal.

1. By far the major portion of Bengal is deltaic, having been built up by the silt carried by her rivers. Absence of marine deposits and presence of fresh water deposits up to a depth of about 1,300 ft. (no deeper borings yet made) seem to indicate that marine conditions never existed up to this depth. The soil composing the upper strata is, however, quite different from that of the lower strata and it appears that the upper delta that we find to-day consisting of blue clay and sand, has been built upon another older delta consisting of yellow clay and sand, which was depressed permitting of fresh deposits by the present river systems.

2. To appreciate the river problems in Bengal it is necessary to envisage how the rivers functioned and are still functioning in building the land and in raising and extending it towards the sea. Nature has been employing two agents in this task, *viz.* upland flood carriers and the tides. The former have been transporting the building-materials brought in by the rain washings from the catchment areas and, after building and raising the banks along their courses, have been discharging the balance into the sea. Portions of this get consolidated and extend the delta and the rest is dispersed by tidal current along the delta face and remain in an unconsolidated state. Tides while travelling inland pick up the latter almost to the saturation point and perform the same delta building functions as the upland flood carriers, with this difference, that, while the latter function mainly during floods, confined to the monsoon months, tides function twice daily during the whole year.

3. Nature again has been assisted in her task by two favourable factors, *viz.* the steep slope of the Himalaya, which has thus been able to furnish building-materials in abundance, and abnormally high tide level, which has facilitated the distribution of the materials. High tide level has also facilitated transport by water, and it can be truly said of Bengal that her rivers built the land, are draining and fertilizing it and are helping in transporting the produce. In areas where the rivers are still continuing these beneficial activities, as in Eastern Bengal, the country is healthy and prosperous, and where the rivers are deteriorating and these activities have been interfered with, as in Central and Western Bengal, the country is progressively deteriorating both as regards health and productivity of the soil.

River problems in Bengal are thus virtually the problems for Rural Development in Bengal and must be solved if this country, specially

her western and central parts, which used to be very healthy and prosperous even about a century ago, has to be prevented from reversion to swamps and jungles from which she was reclaimed by her rivers.

4. For a proper appreciation of these problems and their solution the rivers in Bengal, having regard to their different characteristics, may be classified as follows :—

Group I. Primary delta-builders originating from the snow capped Himalayas, maintaining perennial flow and navigable. The principal rivers under this group are (1) the Ganges series, which by far is the most important delta builder, (2) the Brahmaputra series, which, after her connection with the Tsampo of Tibet and subsequent addition of the Teesta waters towards the end of the 18th century, is proving to be a formidable rival of the Ganges and (3) the Meghna.

5. Group II. Primary delta builders originating from the low hills of Chhota Nagpur and Santal Parganas, such as the Damodar, the Ajoy, the More, the Cossye and other Western Bengal rivers. These rivers are torrential and though they bring in enormous volumes of flood occasionally, they dwindle down to a mere trickle sometime even during the rains, while during the dry season there is practically no flow. Their contribution towards building up of the delta could not therefore have been much, as compared with that of the Ganges, though it seems that a portion of the eastern part of Western Bengal, which is deltaic, must have been built by these rivers, specially the Damodar and the Cossye. Their value, apart from the question of flood flushing, etc. which will be discussed below, however, lies in their being the only sources available for providing supplies urgently needed for artificial Irrigation, necessity for which is practically confined to Western Bengal.

6. Though the total monsoon rainfall as also its distribution during the earlier part of the crop period are normally sufficient, rain usually fails after the middle of September and the necessity for irrigation is felt in Western Bengal even in normal years. In years of abnormally low rainfall irrigation is urgently needed as an insurance against famine. Owing to the proximity of the catchment areas of these rivers to the areas to be irrigated, river supplies also fail when irrigation is required during periods of scarcity, and without storage it does not seem to be possible to meet the needs of irrigation on a large scale. Again, owing to heavy incidence of rainfall at times, the cost of diversion and cross drainage works is usually rather heavy, out of all proportion with the comparatively small area that could be irrigated by the widely fluctuating daily flow of these torrential streams. Storage works, by impounding during floods and supplementing the dwindling daily flow of the rivers during periods of scarcity intervening between floods, really function like a flywheel in an engine. They can thus enormously increase the irrigable capacity of a stream, especially as the stored water is needed for irrigation not so much in the transplantation season, when though a large amount of water is required the rainfall is usually sufficient, but in the latter part of the crop period when the requirements of crops is the minimum. Storage irrigation schemes are thus likely to be rather profitable undertakings in Western Bengal, and as no rain is usually expected during the dry season and rivers also practically dry up then, they provide the only means by which sugarcane and rabi crop could be grown in these parts. As most of the people live on agriculture irrigation projects supplemented by storage works constructed in the hilly valleys of these rivers of Western Bengal, mostly outside the province, are thus urgently needed for their economic uplift. So far two schemes of outstanding importance have been brought to light and investigated, viz. the Darkeswar Reservoir project and the More Reservoir project to irrigate about 200,000 acres by the former and 432,000 acres by the latter.

7. Group III. Subsidiary delta builders—mainly the lower reaches of rivers in Group I and II within tidal limits, which, apart from continuing the delta building activities along with these rivers, constitutes

very valuable assets by providing cheap transport by water of the produce of the country.

8. In all ancient accounts Bengal is reported to have been healthy and prosperous. About the middle of the 17th century Bernier wrote that Bengal was even richer than Egypt. Even about a century ago Hamilton found Western Bengal to be highly prosperous and gave Burdwan the first rank in the whole of Hindusthan as regards productive agriculture. This area is now one of the worst both as regards health and productivity of the soil. In the eastern parts of Bengal where the rivers are still continuing their beneficent activities, the country is healthy and prosperous. Even in the rest of Bengal there is no dearth of water resources, but the progressive deterioration in health and productivity of the soil, specially in the west and in the centre, is due to their faulty distribution. Through many a stream more water flows than is necessary causing disastrous floods, while at other places decrease in flow through natural waterways has caused serious deterioration rendering them even incapable of draining the country side. Indeed many of these streams, which were intended by nature to spill over the land which they traverse and keep it in health and plenty by supplying the rich silt of the Ganges, Damodar, etc., have now been converted into stagnant pools of water breeding mosquitoes, and many a district, specially in the centre and west, has been rendered extremely unhealthy with decreasing population and with land gradually going out of cultivation.

9. This faulty distribution of the water resources, which has been effected partly by human interference and partly by natural causes, constitutes the main river problem in Bengal. Nature has provided her with water resources in abundance and their equitable distribution is now vitally needed for the Rural Development. These problems will now be examined somewhat closely by dealing with these groups of the rivers separately and examining a representative type of each group in detail.

Rivers of Group I.

10. The areas which have been adversely affected mainly due to natural causes, i.e. by changes in the courses of rivers, are :—

(1) Central Bengal due to diversion of the Ganges through the Padma towards the beginning of the 16th century.

(2) Northern Bengal due to diversion of the Teesta through her present course towards the end of the 18th century and

(3) Portions of Mymensing District due to the diversion of the Brahmaputra through the Jamuna channel soon afterwards. There is no controversy as regards the last two changes as they occurred comparatively recently and can be definitely proved by Rennel's maps. Even as regards the first it was taken to be an established fact hitherto; but as this theory has recently been challenged by late Sir William Willcocks I propose to examine this question in detail and take up the Ganges as the typical representative to illustrate the problems arising from this group of rivers.

11. According to Sir William the Bhagirathi and other rivers in Central Bengal were, originally, really canals excavated by the old Hindu Rulers of Bengal. But the following considerations will show that this theory is absolutely untenable.

Large extension of the delta towards the west as compared with that in the east can only be explained by the fact that the main volume of the Ganges flood must have passed down the Hooghly and the contiguous estuaries just to the east for a much longer period than along the present course, unless it can be shewn that there was another delta builder serving the western side of the delta with flood discharge even larger than that of the Ganges, Brahmaputra and the Meghna combined. No such delta builder exists to-day nor could they have possibly existed

in the present geological epoch, as the combined catchment area of all the rivers of Western Bengal does not exceed 25,000 sq. miles as compared with 397,000 and 361,000 sq. miles which are the catchment areas of the Ganges and Brahmaputra respectively. There are also other religious, traditional and historical evidences as given in the main paper in support of the established theory that the Bhagirathi constituted the main channel of the Ganges till the 16th century when—and this is a natural characteristic of the deltaic rivers as explained in the main paper—the Ganges diverted along the present Padma channel.

12. Central Bengal has really been built up by the Ganges which, in the olden days, used to distribute her waters through the Bhyrab, probably the easternmost branch, and the Bhagirathi which again trifurcated into three branches at Tribeni—the Bhagirathi, the Jamuna and the Saraswati. As a consequence of the diversion both the latter branches as also the Bhyrab are now dead. Two other spill channels, the Jalangi and the Mathabhanga, opened up comparatively recently, but they are also dying and get completely cut off from the Ganges during the dry season. Even during the monsoon they can no longer draw enough water from the Ganges to feed their distributaries, which used to distribute equitably the Ganges flood over the whole area and which, in consequence, are now mostly dead. Only the Bhagirathi is now more or less active in the lower reaches thanks to the occasional floods that she receives from the rivers of Western Bengal and to the tidal flushing and other conservancy measures of the Calcutta Port Trust. But in her upper reaches she remains cut off from the Ganges except during the rains when she gets only a mere fraction of her former discharge. In her lower reaches also she is gradually deteriorating and additional supply of upland water is urgently needed not only in the interest of Calcutta as a port but also for her drinking water supply, to arrest the gradual advance of the salt water limit up the Hooghly.

13. Solution then lies in the restoration of the Ganges spill as far as possible through the three principal channels, the Bhagirathi, the Jalangi and the Mathabhanga. As hydraulic conditions are now much more favourable down the Padma channel, the point to be considered first is whether sufficient quantity of spill could at all be extracted from her and diverted through these channels for flushing Central Bengal without a barrage, the cost of which will of course be prohibitive, and without waiting for an indefinite period till nature, after raising the present spill areas in Eastern Bengal, turns her attention again to Central Bengal. Having regard to the characteristic of deltaic rivers, this latter contingency is probable, but the present condition of Central Bengal as regards health and productivity of the spill is so deplorable that unless the area could be flushed by the Ganges spill in the near future the area will revert to swamps and jungles from which it was reclaimed by the Ganges in the olden days.

14. These spill channels from the Ganges pass through successive phases of deterioration and improvement, depending on the position of the off-take with reference to the main channel. The present position of these off-takes, specially that of the Mathabhanga, is definitely improving as the huge char that hitherto marked this off-take has been washed away due to changes that are taking place in the regime of the Ganges. But mere improvement of the off-take is not sufficient. To be able to fully utilize this natural tendency to our advantage the carrying capacity of the channel as also that of the outlets have to be improved, so that the increased discharge that could be drawn due to the favourable position of the off-take could be efficiently disposed of.

15. This again is not enough. Unless these channels are allowed to spill over their banks a good portion of the silt content of the flood entering them, which the reduced velocity due to flatter gradient in their lower reaches is unable to transport, they will naturally deposit in their beds and the channels will again deteriorate. Dredging, though neces-

sary initially to increase their carrying capacities, cannot be relied upon to maintain these channels permanently, for, apart from cost, spoil bank will, within a few years, reach a height beyond the lift of dredgers. Apart from its necessity to improve the health and productivity of the soil, extensive land spilling during floods, therefore, seems to be an essential requirement even for maintaining these channels in deltaic Bengal, which carry such a large proportion of silt. To what extent land spilling may be technically and practically possible can only be ascertained after a contour survey, as there are large vested interests which may be adversely affected by the flooding, necessitating the requisite protective measures. But there seems to be no doubt that in the lower areas which have been prematurely reclaimed, the present method of cultivation will have to be changed, necessitating the introduction of a substitute crop, which can be harvested before the Ganges begins to rise in August, or East Bengal paddy which grows with rise in the water level.

Rivers of Group II.

Primary delta builders originating from the Chhota Nagpur and Santal Parganas hills.

16. Problems of these rivers with reference to artificial irrigation needed in Western Bengal have already been dealt with. Thanks to human interference with their beneficial activities these rivers have, however, presented rather unique and complex problems which will now be considered. The area affected has been built up by them and is flat. But before it could be raised sufficiently by silt deposit during flood flushing it was prematurely reclaimed by flood embankments. But owing to inefficient maintenance breaches were frequent. The land could then get occasional flushings and it did not deteriorate in those days so seriously as it has done now. For more efficient maintenance most of these embankments were gradually taken over by Government and in consequence the breaches are now rare and even when they occur they are closed immediately thus depriving the land even of those occasional flushing of the earlier days. The result has been that the net work of spill and drainage channels within the enclosed area are now dead and can no longer function even as drainage channels. In fact, their beds have also been cultivated at places and they have been converted into stagnant pools of water breeding mosquitoes. In consequence the area is progressively deteriorating in health and productivity of the soil, and land is gradually going out of cultivation.

17. Again the floods being unable to spill are depositing a portion of their silt content within the river channels, thus raising their beds, and as the protected areas, instead of rising by silt deposit, are probably getting gradually lowered due to surface washings caused by the local rainfall, drainage by gravity is becoming more and more difficult and in some areas it has already become impossible. The flood level is also rising necessitating higher and higher embankments and increasing the potential danger to life and property by concentrated discharge through breaches, which can hardly be avoided in earthen embankments subjected to high pressure of sudden floods of these torrential rivers. In fact the position is very serious and unless a bold policy of improvement is followed in the near future—delay will make the solution more and more difficult—these embanked areas of Western Bengal will gradually revert to swamps and jungles from which these were reclaimed prematurely by man.

18. The ideal solution will no doubt be to restore the old condition by the removal of the embankments. Where practicable this solution should certainly be adopted. This will no doubt inundate the area occasionally during floods. But the depth of inundation will be much less than what is now caused by concentrated discharge through breaches, while there will be no danger to life and property, as the removal

of the embankments allowing the flood to spill over a large area, will automatically lower the flood level. The floods of these torrential rivers also do not last more than a few days at a time and will increase the outturn of crops by fertilizing the land with the rich silt carried by these rivers. In years of exceptionally high floods or when floods occur before the seedlings have taken root into the soil, crops will no doubt suffer but this occasional loss will be more than counterbalanced by the increased outturn in normal years and by the improvement in health.

19. But in many cases owing to large vested interests such as railways, towns, etc., protected by these embankments as, for instance, in case of the Damodar left embankment, it is now hardly practicable to adopt such an ideal solution. Here we must be satisfied with the nearest practical approach to this ideal solution, i.e. water should be drawn through controlled escapes to be constructed at suitable places in these embankments and utilized in giving a copious flushing to the starved land during floods. One such project is now under preparation for irrigating and flushing an area of about 3,50,000 acres protected by the Damodar left embankments in the Burdwan, Hooghly and Howrah districts and there is room for a good many more similar schemes.

20. But though such schemes will probably find a solution to the sanitary and agricultural problems created by these rivers due to human interference with their natural activities, they will offer no solution to the rather serious problem with regard to their maintenance. This problem, which is becoming more and more serious owing to the delay in finding a solution, has been examined somewhat in detail in the main paper, taking the Damodar as a representative type of this group of rivers. To protect the area on the left bank, with large vested interests, from the disastrous consequence of frequent breaches through the left embankment of the Damodar, the right embankment was abandoned sometime in the middle of the last century. But this very fact, by raising the right bank by annual silt deposit, has now made an avulsion of the Damodar, with the maximum flood discharge of about 6½ lacs cusecs, through the left bank towards the Hooghly, a very probable contingency. Such an avulsion will of course be a disaster of the first order, for, apart from damage to vested interests on the left bank, the important city of Calcutta and the large business interests on the Hooghly will be in danger as this channel in her present condition cannot possibly carry even a material portion of this discharge.

21. Uncontrolled escapes towards the left are of course out of the question, and even controlled escape of a material portion of the Damodar flood, sufficient to afford a relief, has to be ruled out for the above reasons, apart from the question of prohibitive cost of the necessary work. As it is neither possible to increase the capacity and maintain the channel by dredging, the only feasible alternatives seem to be either to construct flood moderating reservoirs in the hilly valleys or to provide an escape through the right bank into the Rupnarain.

Group III. Tidal rivers.

22. The lower reaches of the rivers of Groups I and II are tidal, and apart from discharging drainage and other beneficent activities, they perform the important function of carrying the produce of the country. Where these activities have not been interfered with by acts of man they are still discharging these functions, though, being now deprived of the supply of upland water, these tidal channels in the southern portion of Central Bengal are gradually deteriorating and will ultimately cease to function, except perhaps as regards drainage, as soon as the spill areas have been raised to near about the high tide level. But where man has interfered by prematurely reclaiming the spill area of these channels by means of embankments the position has already

become rather serious as, while these areas have remained low, the channel bed has risen by silt deposit making drainage by gravity already impossible in many cases. A distinction should be drawn in this connection between an upland flood carrier and a tidal channel. As the upland flood must be disposed of ultimately into the sea, when the former deteriorates it changes its course and its beneficent activities are not lost to the country, only they are transferred elsewhere. When however a tidal channel deteriorates it dies in its own bed and its beneficial activities are lost to the country. Thus the death of these tidal channels will mean that the only agents now left by nature for raising the tidal portion of Central Bengal will be lost to the country for ever. It will then be impossible to drain the area by gravity which will gradually revert to swamps and jungles from which it was prematurely reclaimed.

23. Solution lies in removal of the marginal embankments and other obstructions so that these areas may be adequately raised before they are reclaimed. But though this will certainly prolong their life it would not be sufficient to preserve these tidal channels permanently as carriers of the country's produce nor to arrest the rapid advance up the delta of the salt water limit, for which purpose a supply of upland water seems to be essential. As this point is not usually understood, physical characteristics of tidal rivers are explained in the main paper establishing the fact that to maintain the life of a tidal river additional supply of water is required to reinforce the flushing during ebb, which, without this reinforcement, is unable to clear the bed completely of the silt deposited during flood tides. As the supply given by the local drainage can be counted upon only during about five months of the monsoon, and the supply from the spill area will gradually disappear as this area rises by silt deposit, the only means of preserving the life of a tidal channel permanently is by providing a supply of upland water. Improvement of the spill channels of Central Bengal and diversion of a portion of the Ganges water thus seem to be necessary even for maintenance of these tidal channels.

24. The life-history of the Bidyadhari is given in the main note to illustrate these points. The history is reconstructed on the basis of indisputable evidence left by nature in her banks. These natural banks just above Bhangore Canal are found to be much higher than the tide level and must therefore have been built up by the upland floods; and the width between crests of these banks must give a rough measure as regards the volume of such floods which the Bidyadhari used to receive in the olden days. It appears from these and other evidences, as explained in the main paper, that the Bidyadhari was an important spill channel of the Jamuna and when this river was active, she used to draw a considerable volume of upland floods for her sustenance. After the diversion of the Ganges and subsequently of the Damodar the Bidyadhari was deprived of the supply of upland water and began to deteriorate.

25. But the existence of the vast spill area in the salt lakes should have enabled her to continue her beneficent activities, including the raising of the salt lakes, thus removing the nuisance so close to Calcutta, and the disposal of Calcutta's drainage, but for the acts of man. These acts were the premature reclamation of the land on both banks of the Matla and the Bidyadhari by means of marginal embankments as also the fisheries in lower areas interfering with free spill, the discharge of solid sewage and lastly the construction of the Kristopur Canal. The Bidyadhari is now absolutely dead beyond any chance of revival and the serious problems that have been created as regards drainage of areas near about Calcutta should serve as an object-lesson to those who are interfering with these tidal channels. In fact the Peali is also fast deteriorating and will soon share the same fate with the Bidyadhari, and immediate steps are necessary to prolong the life of this river to save a large portion of the 24-Pargannas District, now served by this

river, from reversion to swamps and jungles from which the area was prematurely reclaimed by man.

26. Another problem that is gradually becoming more and more difficult with the deterioration of the tidal channels in Central Bengal is in regard to the valuable services which the rivers of groups I and III are rendering by providing a cheap means of transporting the country's produce by water. Together with Eastern Bengal, the tidal portion of Central Bengal possesses an important asset in the magnificent waterways. The principal highways—the Ganges, the Jamuna, and the Meghna—which connect Bengal with the neighbouring provinces of Bihar and Assam, need very little attention, and during the rains when the country is inundated goods from almost every village in Eastern Bengal can be carried by water to these principal highways and through them to the different trade centres including Calcutta. But a good portion of the discharge of the Ganges is being intercepted by the upper provinces for purpose of irrigation, and it seems necessary to watch these developments and adopt necessary measures, as further interception of the Ganges discharge during dry season is likely to adversely affect not only the prospective scheme that may be taken up for the improvement of Central Bengal but also navigation through the Ganges.

27. But the main problem that we have to face at present is with regard to the feeder channels connecting these principal highways. specially with Calcutta. During the earlier period of British Rule the Bhagirathi, the Jalangi and the Mathabhanga were being utilized as feeders from Calcutta to the Ganges, though even in those days there were difficulties of navigation during the dry season and various attempts were made to keep the Mathabhanga navigable throughout the year. As this was found to be more and more difficult the Calcutta Canal route to the east through the Sunderbans was opened early in the 19th century and gradually improved. These works, however, were intended for boat traffic but steamers, when they came into the picture, were following the route via Tolly's Nullah (excavated in 1770), the Bidyadhari, the Matla, etc.

28. Owing, however, to the death of the Bidyadhari, and consequently of the Tolly's Nullah, the steamer route through the Sunderbans is being shifted more and more towards the seaface. Here again nature has helped us by providing cross connections between the north-to-south delta builders. An explanation has been given in the main paper regarding the origin of these cross channels which are found to be so very valuable in the interest of navigation. But, owing to tides entering from both ends and meeting within the cross channel, thus gradually deteriorating it by dropping of silt, many of these channels have disappeared throwing the steamer route more and more towards the sea. In fact our main problem at present in respect of waterways for navigation is with regard to the maintenance of these cross connections, though the maintenance of the north-to-south channels in Central Bengal is also proving to be difficult and, in the purely tidal areas, will be impossible ultimately, unless steps are taken for a supply of upland water as already discussed while dealing with these rivers under group III.

29. The rivers of group I are also presenting a problem which is really inherent in the very nature of delta builders passing through very friable soil, as in Eastern and Northern Bengal, in the shape of erosion of their banks, and it is being aggravated by the natural tendency to concentrate all available flow through the two principal channels, the Ganges and the Jamuna. Diversion of portions of this flow through Central and Northern Bengal, as discussed above, will mitigate this problem to a certain extent.

30. In conclusion it may be mentioned that the all-important factor which dominates the river problems in Bengal is the large proportion of silt carried by the flood. As will be seen from the above (more fully dealt with in the main paper) though silt has proved to be one of our greatest benefactors, in some respects, it has also been a malefactor, and we

ought to make the closest study of this all-important factor. Beyond general knowledge as indicated above we, however, possess very little information on the subject. What is required is a Research Officer with a fully equipped laboratory to study this and other questions amenable to laboratory treatment, thoroughly and scientifically to guide us in our effort to solve the rather complicated river problems in Bengal. Many of these problems are unique without any parallel. Practices followed elsewhere will not therefore help us much but we have to find a solution ourselves by long and concentrated study of the local conditions.

10. PROF P. C. MAHALANOBIS, Calcutta.

River floods in Orissa.

The Orissa delta is a long narrow strip of alluvial land with an average width of about 40 or 50 miles. The total area is about 8,000 sq. miles, of which 2,300 sq. miles drained by the Mahanadi and 800 sq. miles by the Brahmani and Baitarini are especially subject to serious floods during the monsoon season. The Mahanadi has a total course of 500 miles with a drainage area of 50,000 sq. miles, and a maximum flood discharge of two million cusec. The drainage area of the other rivers is about 20,000 sq. miles.

About four-fifths of the annual precipitation is concentrated within the four monsoon months. Analysis of rainfall records do not reveal any appreciable seasonal or cyclic trends, so that the rainfall régime may be considered to be fairly stable. The areal distribution and frequency of occurrence of different intensities of rainfall from one to ten consecutive days have been studied in detail and furnish basic hydrological data for schemes of river control.

Analysis of daily heights of the rivers do not reveal any evidence of progressive deterioration of the channels. Frequency distributions of river heights from one to ten consecutive days have been prepared from which the actual risk of floods of any given height can be obtained with precision. The frequency of occurrence decreases in logarithmic proportion up to a certain definite height of the river which probably represents a critical transition state of the hydrological system.

Floods are caused by the heavy rain given by storms and depressions from the Bay of Bengal which move across the delta and the river basins roughly in west-north-westerly direction with an average velocity of 8·5 miles per hour, and which remain within the catchment area for about two days. The rainfall in the period immediately preceding a serious flood usually occurs in a well-marked patch of very heavy rainfall of over one inch per day for three consecutive days followed by moderately heavy falls for two or three days more. Heavy rain first occurs in the delta, and then in the more westerly portion of the basin. It therefore takes some time for the flood water to reach the delta. The crest velocity is about four miles per hour, and usually there is a lag of about three or four days between the maximum rainfall in the basin and the maximum flood at Naraj. Usually the river rises for three or four days, beginning to fall slowly from the fifth day.

The river channels in the delta are quite inadequate in their present condition to carry the flood water which in the case of a severe flood may amount to twice the capacity of the channels. Local rainfall in the delta by itself cannot cause a flood of importance but such rainfall can seriously aggravate the situation by increasing the intensity or duration of the flood.

Correlational studies showed that on an average the level of the Mahanadi rises by about 20 feet for an increase of one inch of average rainfall over the whole basin. The connexion is however not sufficiently close to enable individual forecasts being made in time to be of practical use.

Correlation between gauge readings at Naraj (near Cuttack) and at Sambalpur is very high, and it is possible to predict the height at Naraj within a few inches from twenty-four to thirty-six hours in advance.

In the case of the Brahmini similar correlational studies show that the condition of the river channel has remained more or less the same during the last 30 or 40 years, so that there is no evidence in support of the theory that the bed of the Brahmini was suddenly raised by two or three feet after the severe flood of 1926.

Normal monsoon precipitation in the catchment basin is of the order of 900 kilo-cusec per day while the rainfall intensity in the delta itself is only 30 kilo-cusec. Most of the flood water is therefore brought down by the rivers. During the monsoon the river emerges from the hilly country with high velocities and heavily laden with silt. On reaching the plains the velocity is suddenly reduced and the silt is deposited on the river-beds. The bed of the river rises in consequence and forms a shallow ridge on the summit of which the river flows. Gradually the bed is raised so high that the river bursts its banks and sends out branches. Fresh ridges are formed by the deposit of new silt, and the whole process is repeated over and over again. In this way the Orissa delta has become covered by about 15 main branches with innumerable minor streams within a distance of 40 or 50 miles.

Along the sea-coast of Orissa there exists a steady northward littoral sand drift which tend to form bars across the mouth of the river from south to north. The rivers are continually trying to form new land by deposit of silt, but this silt is continually being forced towards the north by this littoral drift. This is a peculiar characteristic of the Orissa coast, which explains the fact that the head of the delta is situated only 40 or 50 miles from the coast line whereas in the case of the Ganges or the Indus they are about 400 miles from the sea. Conditions in the Orissa delta are at present in a kind of dynamic equilibrium.

The escape of flood water is seriously obstructed by embankments, and also by canals and roads. Flooding is thus often inevitable in this area under existing conditions. The erection of flood-retarding reservoirs in the catchment area, improving existing channels, and removal of obstructions to drainage in the delta require planning on a large scale. It is desirable that detailed hydrological studies and small-scale model experiments should be undertaken for this purpose. Flood forecasts, construction of emergency refuge mounds, and other ameliorative measures can be undertaken in the meantime.

XXV. COLLOIDS IN BIOLOGY, MEDICINE, AND AGRICULTURE.

(Sections of Chemistry, Zoology, Medical Research, Physiology, and Agriculture, in co-operation with the Society of Biological Chemists, India.)

Prof. S. S. Bhatnagar presided.

1. Prof. J. N. Mukherjee, Calcutta, opened the discussion.

The subject-matter of the present discussion is very comprehensive, and in order to avoid being diffuse I shall restrict myself to those aspects of the properties of colloidal systems, which serve as a connecting theme regarding their rôle in biology, in medicine and in agriculture. Even then I shall restrict myself only to some fundamental considerations of the subject. It would, however, be helpful briefly to discuss what we under-

stand by colloidal systems. Historically, the distinctive properties of colloids rest, according to Graham, on their slow diffusion, their inability to pass through parchment and similar membranes and the difficulties of obtaining them in a crystalline form. These characteristics, which were thought to distinguish colloids from the 'true' solutions of crystalline substances, were later found to be inadequate to classify substances into mutually exclusive 'worlds of matter', namely, crystalloids and colloids. For crystalloids were obtained in a colloidal condition and *vice versa*, and we began to speak of the colloidal state of matter. This, however, is again a vague term, and the vagueness is best illustrated by the so-called physical and chemical theories contending sway in the treatment of colloidal systems. In fact references to these theories have become so commonplace that their contents are often taken for granted and it is seldom that questions were asked till recently as to what they really connote. Even at the present time opinion is far from being unanimous. I have discussed this question in several publications, and I shall briefly refer to some criteria, which will serve to bring out the characteristic properties of colloidal solutions and systems and to reconcile, to some extent, though not completely, the postulates of these two theories. It will also serve the purpose of inviting discussion on these central themes in the theoretical treatment of colloidal systems.

Differences of optical heterogeneity, though useful as a rough guide, do not serve as satisfactory criteria. For they depend on the wave length of light used and the size, shape, and the arrangement of the particles. They do not bring out the differences of systems, in which the thermodynamic equilibrium can be treated unequivocally in terms of well defined components and phases, with those in which their properties cannot be so treated. The question arises how far colloidal particles can be treated as molecules.

It is true that the kinetic theory affords a satisfactory definition of molecules in terms of the translational energy of the different particles, either in the liquid, solid or gaseous state. Let us call a particle, which answers this criterion, a *physical molecule*. In cases where the kinetic theory falls short the quantum theory, in its simpler formulations, still enables us to distinguish these physical molecules on the basis of the probability of the distribution of their translational energy. But this criterion is too comprehensive and it is often not possible to distinguish a colloidal particle from true molecules. Where colloidal particles show Brownian movements they surely behave as physical molecules in the above sense.

Fortunately the definition of *a chemical individual*, in terms of Gibbs' criteria of a *component* in chemical systems in thermodynamic equilibrium, serves as the most helpful criterion. Let us then call the components in all such systems as *chemical molecules*. The terms heterogeneity and homogeneity now assume a different but unequivocal significance. Following Gibbs we see that in all systems, ordinarily met with in chemical equilibria, the magnitudes of the internal energy, of the entropy, of the free energy, of the thermodynamic potential, are single valued functions of the number and concentrations of the different components present in the system, and the two external variables, pressure and temperature. Now in ordinary chemical equilibria the interface, interfacial energy and the individuality of the different portions of any homogeneous phase which are present in the system are neglected. But when the degree of dispersion is great the magnitude of the interfacial energy makes its effect felt. We may therefore usefully define colloidal systems as those systems whose behaviour show definite departure from that predicted by classical chemical thermodynamics, in the sense that considerations of interfacial energy and of the conditions existing at the interface are necessary for the elucidation of their behaviour. Though this definition does not encompass all types of colloidal behaviour, it helps us to find a more comprehensive definition and we may define colloidal behaviour generally as those properties which owe their origin to the presence of an interface, to the

mutual arrangement and association of individual portions of homogeneous phases and the shape and size of the individual portions. In consequence, colloidal behaviour, met with in different branches of science, admits of a great measure of co-ordination.

Electrification at interfaces and interaction of colloidal systems with electrolytes.

One of the properties of interfaces, which differentiate them from a homogeneous phase, is illustrated by the conditions of electrification which are often met with in interfaces. Inside a homogeneous phase the following conditions are invariably held to be satisfied; a constant chemical composition, a constant chemical potential and electroneutrality. By this statement we understand that across any plane, covering a sufficiently large number of molecules, both the chemical potential and chemical composition have constant values and the net electrical charge is zero, independent of the location of the plane. In interfaces, however, either as a result of orientation of molecules and their polar character, or of the distribution of electrified particles, usually electrolytic ions, planes parallel to the interface may show a variation in the chemical composition, the electric potential, and the net electrification. In consequence, surface pressure, surface orientation, surface potential, and the potential of the electrical double layer assume considerable importance in the study of colloids.

Let us consider two colloidal systems of widespread interest namely, proteins and the inorganic colloids present in soil. The types of interaction between proteins and electrolytes are many and diverse. The first attempts, following the lead given by Duclaux, Michaelis Pauli and McBain, which aimed at the systematization of the vast experimental material, were based on an application of the concepts of classical electrochemistry to these systems. Proteins are treated as ampholytic systems with definite acidic and basic dissociation constants. And we are familiar with the nomenclature of Michaelis namely, the designation of colloidal systems having electrolytic properties as 'acidoid', 'basoid' and 'saloid' systems. The concepts of classical electrochemistry are assumed to be applicable, but there is also an implied recognition that certain peculiarities arise out of the large size of the protein molecule or ion. These theoretical treatments often suffer from a good deal of vagueness, which masks the important question whether these classical concepts are capable of *ad hoc* application, that is, whether there are not definite facts which contradict some unambiguous deductions from them. The investigations of McBain on soaps, which led to the formulation of the expression 'colloidal electrolytes' and a definite idea regarding the peculiarities of the electrolytic conductivities of micelle ions', established some characteristic differences of these systems from ordinary electrolytes. But they were considered to be only a peculiar class of electrolytes, amenable to the usual theoretical treatment. Indeed, McBain has denied the usefulness of the concept of an electrical double layer which he calls 'the fictitious electrical double layer'. Certain calculations and theoretical considerations by the speaker, however, show great discrepancies in the conductivity of such colloidal systems from that deduced from the basic theories of electrochemistry in their present forms. Recent experimental investigations in several laboratories have focussed attention on these differences. The dissociation constants, degrees of dissociation, total acidities, activity and conductivity coefficients have no such unequivocal meaning as in the case of usual electrolytic systems. Such investigations have mostly been carried out, in this laboratory, with inorganic colloidal systems such as aluminium hydroxide, silicic acid, hydrogen clay (which is more complex) and also with comparatively simple organic substances such as straight chain sulphonic acids, e.g., Undecyl-Lauryl-, and Myristyl-sulphonic

acids by McBain and Betz and cetyl-pyridinium and cetyl-trimethyl ammonium bromides by Hartley. McBain concludes that micelle ions cannot be regarded as mere polyvalent electrolytic ions.

Recent work in the speaker's laboratory illustrate not only the usefulness but also the necessity of the concept of the electrical double layer, a point of view, which has been emphasized by Wiegner and his co-workers in their researches on clay systems. It is very difficult and at the same time obviously necessary to obtain unambiguous evidence that the deductions from classical concepts are contradicted. Interactions of silicic acid, aluminium hydroxide and hydrogen clays with electrolytes appear to afford such evidence. Most of these colloidal solutions should be treated as polyphase systems, but it is difficult to define the phases. It also appears reasonable to conclude that often the equilibrium is between the double layer and the ions in true solutions. Considerations of the adsorption of ions, which are so important in a number of colloidal phenomena, are helpful. Ion-pairs formed on the surface of the colloidal particles seem to govern the equilibria. An interesting instance of the formation of such ion-pairs is afforded by the works of Ghosh and of Chlopin and Balandin on precipitated manganese dioxide.

Compared to the inorganic substances, referred to above, the protein systems offer points of difference; the former are known to be insoluble and their colloidal solutions should be regarded as polyphasic. It is, however, difficult to ascertain the solubility of proteins. There is, however, the important researches of Sorensen, which show that some proteins, prepared with great care, show a definite solubility. It is, however, necessary to point out that a reproducible constant composition of the solution in contact with the solid material of the protein at a single temperature, does not necessarily imply a constant solubility; for constancy of composition of a substance and of the liquid phase in its contact, is not, in itself, a sufficient criterion of its chemical individuality. It is necessary to show that the observed solubility, or rather the constant activity of the protein at a given temperature, would explain a sufficient number of chemical equilibria in which the substance takes part, just as the run of a curve cannot be depicted by a single point. If, for example, in addition to a constant solubility, the heat of formation of the saturated solution and the relevant specific heats are known, so that a temperature solubility curve satisfying thermodynamic criteria can be constructed, the identification of a given protein as a pure substance, i.e. a single component or a chemical individual, could be established. Unfortunately proteins are very susceptible to changes, even in contact with simple electrolytes and time also acts as a factor. Besides on account of the large value of their molecular weight, a small concentration of other components, from which it is often difficult to separate them, may considerably affect the molecular composition of the system. The increasing number of well-crystallized substances of high molecular weight, however, may be taken to indicate that it is difficult *a priori* to set a limit to the size of a chemical molecule. From the above it would appear that though protein systems show many instances of typical colloidal behaviour they lie on a border land.

The colloidal dimension.

Protein systems offer an instance of the difficulty of differentiating colloidal from molecular systems on the basis of the size of the ultimate particles taking part in chemical reactions. Colloidal solutions of gold may have very small particles, whose size is very much less than that of many truly dissolved molecules. The process of formation of a saturated solution represents a spontaneous splitting of the mass into ultimate particles, the size and number of which are completely defined. Conditions are different in colloidal solutions. Attempts have been made (e.g. Donnan, Tolman) to build up a thermodynamic treatment of systems of

colloidal particles, based on the similarities and by including surface energy amongst the variables which are taken to determine the total energy in chemical thermodynamics. We know that oil disperses in water in the presence of suitable emulsifiers. It appears to simulate the process of solution. The size distribution curve, however, depends on the emulsifier and the condition of the emulsification. But in most cases the emulsions can be shown to constitute a heterogeneous system. If we take the simple systems of a number of droplets of a pure substance, enclosed in a given space, they can only be in stable equilibrium so long as they do not come in contact and if the vapour pressure of each particle be the same. The curvature and hence the size and the shape must be identical. If, however, some of the particles are electrified and some are not, particles of different size and shape may be in equilibrium. Similarly, if instead of a pure substance we take drops of a solution, particles of different size and shape may also be in equilibrium. Besides, the interface is the seat of chemical interactions which lead to a displacement of equilibrium, formation of molecules not equally stable in the contiguous homogeneous phases, and the orientation of molecules. They also affect the kinetics of chemical reactions. These considerations illustrate that the interactions of various sources of energy at the interface may lead to a stable equilibrium between particles of different size and shape, even though the system as a whole is not homogeneous, as ordinarily understood. But in contrast to ordinary chemical equilibria, the conditions obtaining in these systems do not seem to lead to a permanent adjustment between the different sources of energy. In fact, this want of permanent adjustment seems to mark the fundamental characteristics of colloidal systems, specially the biocolloids which are in addition very susceptible to chemical changes. To this feature may be ascribed their importance and association with bioprocesses and biological systems. They admit of more continuous changes which are brought about by small changes in the absolute value of energy. It is therefore not so much the size of the particle but the nature of interfacial energy and the ease with which the association between the individual particles on the one hand and that between the particles and the 'dispersion means' on the other, which characterize colloidal systems and their importance in such widely different branches of science as meteorology, geology, soil science and biology. The size is of importance only in so far as the size determines whether interfacial energy has attained a magnitude comparable with the contribution of the other factors to the total energy. In purely physical processes, such as Brownian movement, rate of settling, the scattering of light and others, the dimension of the particle has of course its importance.

Solvation and structure.

The relation between the particles and the 'dispersion means' is illustrated in agriculture by the speculations regarding the manner in which the moisture is associated with the soil and in protein systems by their hydration. The mutual relationship between particles is well illustrated by the stream double refraction of certain colloidal solutions. We have to consider in addition to the 'isotropy' and 'anisotropy' of the substance in bulk, of which the particles are composed, the 'isometry' and 'anisometry' of the particles. The elastic properties of gels illustrate the importance arising out of the structural arrangement of the particles. The interplay of solvation, structure, the electrical double layer and surface tension give rise to such characteristic colloidal properties as coagulation, syneresis, shrinkage, swelling, solation, gelation, thixotropy, antagonism, dilatancy, plasticity, etc.

A similar difficulty regarding the differentiation between the colloidal and crystalloidal systems arises when one considers solvation and structure. Solvation and formation of hydrates, solation and solution, gelation and

salting out, crystal structure and gel structure are pairs of phenomena which show some similarities between themselves. The imbibition of moisture by gels which often lead to swelling shows considerable similarity to the absorption of moisture by some crystalline substances, e.g. chabasite. In quite a large number of cases the criteria set forth above help us to differentiate between these parallel types of behaviour. But when we come to the border land, represented mostly by biocolloids, the differentiation loses its sharpness. Ultimately a general theoretical treatment will be available, which will reconcile these differences and fully account for the similarities. The possibilities of such a reconciliation in the case of the simpler inorganic colloids, in so far as their interactions with electrolytes are concerned, have been indicated by the speaker in a recent publication.

3. Dr. A. N. Puri briefly referred to some special problems of Soil Chemistry.

There was a short discussion in which Prof. S. S. Bhatnagar and Prof. V. Subrahmanyan joined among others.

XXVI. RELATION OF ZOOLOGY TO MEDICINE, VETERINARY SCIENCE AND AGRICULTURE.

(*Sections of Zoology, Medical Research, Veterinary Research, Entomology, and Agriculture.*)

A joint meeting of the sections of Zoology, Entomology, Medical Research, Veterinary Research and Agriculture was held in the Auditorium of the All-India Institute of Hygiene on January 5, 1938, at 1-30 P.M. Col. R. B. S. Sewell was in the chair. The meeting was largely attended and a number of Oversea delegates participated in the discussion.

1. Dr. Baini Prashad, Calcutta, opened the discussion.

Detailed biological and ecological studies carried out all over the world have clearly shown the great dependance of the various types of plant and animal life on one another, and the very great influence exerted by some of them on the different types of food-crops, fruit-trees, animals, etc., which are so essential for the existence of human life. The great advances made within the last half a century or so in the study of diseases and parasitology have further shown the very great importance of the various classes of animal parasites, particularly protozoans and helminths, in connection with health problems, not only of mankind but also of the various classes of domestic animals. In connection with the latter, the importance of Animal Husbandry, particularly in reference to their breeding, selection and genetics, has opened up very wide fields of research.

In opening the discussion on the relation of Zoology to Medicine, Veterinary Science, and Agriculture the author discussed briefly the interrelationships of these subjects along the lines indicated above. In regard to Veterinary Science and Agriculture, the question of biological control was referred to and its importance stressed in connection with any measures that might be suggested or adopted for the control of various animal pests and parasites.

2. Dr. Dev Raj Mehta, Kasauli.

Possible Rôle of Arthropods as Vectors of Typhus.

In the Simla Hills there exist two types of typhus fever, the serum of one agglutinating strain of *Proteus* $\times$K and not $\times$19, whilst that of the other gives the opposite reaction. Cases of typhus $\times$K are reported during August and September and those of the $\times$19 type occur during mid-winter and early spring. Probably this seasonal incidence of the two types of typhus is dependent on the prevalence of different arthropod vectors on the possible rodent reservoirs of infection at these particular periods.

A total of 2,451 rats, mice, and shrews were trapped at Kasauli and Sabathu during 1935-36. The rats are the accepted reservoirs of typhus in other countries and harbour a virus identical to that obtained from human sources.

Amongst the external parasites on these rodents are included the fleas—*Xenopsylla cheopis*, *Ceratophyllus simla*, *Ctenocephalus canis* and *C. felis*, and *Leptopsylla segnis*. The principal mites observed are *Liponyssus bacoti*, *Dermanyssus* sp., *Echinolaelaps echidninus*, and larval forms of *Trombicula*. The ticks are represented by the immature stages of *Hyalomma aegyptium*, *Rhipicephalus sanguineus* and *R. haemaphysaloides*, *Haemaphysalis* sp., and adults of the genus *Ixodes*. The louse *Polyplax spinulosa* is very frequently found.

The fleas (*X. cheopis* and *C. simla*) are the likely vectors of the $\times$19 form of typhus. The possible rôle of rodent ectoparasites as vectors of typhus $\times$K will be discussed.

3. Dr. A. C. Aggarwala, Lahore.

Zoology in relation to Veterinary Science.

In this general paper, the author, after defining Veterinary Science in terms of animal husbandry, has stressed upon the maintenance of animal health and efficiency, including protection from the ravages of disease as an all-important factor in the success of agricultural life and procedure in India. Without a true knowledge of the cause of disease, remedial measures cannot be appropriately determined and effectively applied. The elucidation of the cause of disease, however, is not altogether a one-man issue. There are so many sides of a disease that the definition of causation invariably requires the collective effort and opinion of experts in special sciences before any tangible summing up can be arrived at. A suitable team of research workers, including physicists, chemists, biochemists, botanists, zoologists, veterinarians, etc., must all collaborate and render necessary aid in the survey of circumstances which point to the different aspects of animal diseases. A zoologist is particularly indispensable in the field of Veterinary Parasitology which includes Veterinary Protozoology, Helminthology, and Entomology. Even till to-day comparatively little is known about a number of parasites which set up a variety of diseased conditions in domestic animals and are responsible for heavy losses to the country. Apart from this, a working knowledge of zoology is essential not only to qualify as a veterinarian but also for the everyday duties of a qualified veterinary surgeon. Again, in animal breeding, which has been very aptly defined by Dr. Crew as 'an adventurous experimental study in applied biology', a knowledge of the principles of evolutionary biology and an up-to-date study of the research work carried out by the zoologists in the field is extremely useful. The author, however, does not appear to be very much struck by the ultra-academic sentiment that 'polite learning and true culture admit no contact with utility', and from a practical standpoint and as a veterinary field worker, he points out that while tackling Veterinary Parasitology one

should not become so much engrossed with the parasite as to forget the disease.

4. Dr. M. Sharif, Aligarh.

On the Relation of Zoology to Medicine and Veterinary Science, with reference to Fleas and Ticks.

Fleas and ticks are external parasites of great economic importance. They transmit numerous diseases to man and domesticated animals and are also harmful in other ways. They have thus a direct bearing on medicine and veterinary science and an indirect bearing on agriculture.

(A) *Fleas.*

Fleas affect man and domestic animals in two ways: Firstly as vectors of diseases and secondly as blood suckers and annoyers of man and domestic animals.

The chief interest of fleas centres round their connection with the bubonic plague which is primarily a disease of rodents from which it is transmitted to man by fleas. This disease has played havoc with man from times immemorial and is caused largely, if not exclusively, through the agency of fleas. In India alone upwards of 7,000,000 deaths, due to this disease, occurred between the years 1896 and 1911.

A disease known as infantile Kala-azar, found in countries bordering the Mediterranean Sea, is also supposed to be transmitted by dog or human flea. Fleas are the suspected vector of Kala-azar, though competent opinion is still divided. *Xenopsylla cheopis* can transmit the causative agent of Tsutsugamushi fever under experimental conditions. Hæmorrhagic septicæmia, a fatal disease due to *Pasteurella boviseptica,* in cattle is transmitted by *Ctenocephalides felis.* Fleas can also transmit Rickettsial diseases in man. A flea acts as the intermediate host of the tapeworm belonging to the species *Dipylidium caninum* which is found in dog and occasionally in man.

Besides the transmission of diseases, fleas are troublesome parasites. In many cases they are said to have rendered houses or other places uninhabitable for a time. The Sticktight flea (*Echidnophaga gallinacea*) is responsible in the tropics and certain parts of the United States of America for a considerable annual loss to poultry breeders. The Chigoe (*Tunga penetrans*) causes painful sores in man or even crippling if neglected. During the Great War in East Africa the British Army had to wait for two days to occupy a position of great advantage vacated by the Germans, on account of its being infested with fleas of this species.

Fleas afford us a good instance that a mere systematic study of a group sometimes helps to clear up certain points of great economic importance. The Plague Commission in India failed to understand the reason why certain places having similar ecological conditions had severe plague while others like Madras and Colombo were comparatively immune from it. It was found by Rothschild and Hirst that in the plague-free places the rats were infested with *Xenopsylla astia* which is an inefficient vector of plague bacilli, and in areas infected with plague, *X. cheopis,* which is the most efficient vector of plague bacilli, predominated. Thus a much despised systematic study of this group helped in explaining a puzzle which the trained applied entomologists with enormous funds at their disposal could not explain in a period of seven years.

The ecological work done on fleas by Buxton, Leeson, Sikes, Bacot, and the present author deserves to be mentioned. If the applied workers in this field take advantage of their pioneer work, they will be able to understand the flea problem and thus save humanity from its depradation.

(B) *Ticks.*

The harmful effects caused by ticks to animals and man may be due to (*a*) their bites, (*b*) extraction of blood, (*c*) transmission of diseases, and (*d*) tick toxæmia.

(*a*) *Tick bites.*—It is a well-known fact that the bite of a tick causes ulcers or small wounds which may serve as suitable places for bacterial infections. If the wound caused by a tick bite is large, the eggs may be laid by flies which develop into maggots and cause cutaneous myiasis. Ticks occurring on legs and between digits in sheep and cattle give rise to sores resulting in lameness. The fowls may die of ' tick worry '.

(*b*) *The extraction of blood* by a large number of ticks makes the cattle so weak that they are depreciated in value from the commercial point of view. It makes them unfit for work and in milking animals the yield of milk is reduced to a considerable extent. Repeated attacks by large numbers of ticks shorten the life of animals and make them weak so that they become an easy prey to other diseases.

(*c*) *Transmission of diseases.*—The importance of ticks in general as transmitting agents of various diseases of man and domesticated animals continues to become more manifest as our knowledge of them increases. Smith and Kilborne (1893) made the first remarkable discovery of the possibility of transmission of protozoal parasites by arthropod hosts by demonstrating the transmission of *Babesia bigemina* by *Boophilus annulatus*. This discovery by Smith and Kilborne opened up the vast field of research on the part played by Arthropods in the transmission of protozoal diseases, which has since then revolutionized our knowledge of tropical diseases. In man ticks transmit the causative agents of the relapsing fever (Spirochætosis) all over the world, the Rickettsial diseases like Tick typhus, Marseilles fever and the Rocky Mountain spotted fever of America and Tularaemia. In domestic animals they transmit diseases caused by *Babesia, Theileria, Anaplasma, Bacteria,* and Viruses.

(*d*) *Tick toxæmia.*—According to some observers the salivary secretion of ticks contains toxins, and cases of tick paralysis in some animals and man are generally explained on the basis of their presence. According to Regendanz and Reichenow (1931) the poison causing tick paralysis is specially formed in the female of *Rhipicephalus sanguineus* during the process of egg development. They experimentally showed that injections of eggs or ovaries of this tick just before oviposition gave rise in dogs to symptoms similar to those of tick paralysis.

The ecological studies on ticks have yielded useful results for their control. Unfavourable climatic conditions which are mainly responsible for keeping the number of ticks in check, have been studied in some countries. Ticks have natural enemies both predaceous and parasitic. The study of their effects in limiting the increase of the population is being made at present in some countries. Regarding the parasitic enemies of ticks a serious attempt by highly trained persons is being made at present at Montanna, where a research laboratory costing about sixty thousand dollars was specially built for this purpose in 1927. According to Cooley for the time being the use of tick parasites appears to afford the most promising method of control.

5. MR. M. AFZAL HUSAIN, Lyallpur.

Relation of Zoology to Agriculture.

Agriculture has always been, and will continue to be, the fundamental industry of India. Zoology is intimately connected with this industry. In Indian farming animals play directly a very important part. The cow is indispensable, not simply because it provides wholesome food for human beings, but also because it provides the most essential draught animal—the bullock. The earth resting on the horn of a bullock is a

true representation of the importance of this animal in our agriculture. Besides, cattle are important to Indian agriculture as producers of manure which is so necessary for maintaining soil fertility. Again, cattle breeding, sheep breeding, poultry rearing, apiculture, lac culture, and seri-culture are well-recognized subsidiary industries for a farming community.

Further, animals of various groups directly and indirectly interfere with efficient Agriculture by destroying crops and domestic animals. Protozoa, worms, insects, birds, and mammals include serious foes of the cultivator. Perhaps insects, sparrows, and rats cause damage to our agriculture which is many times more than the cost of armaments, even at the present time of feverish activity in re-arming.

A science, the object of which is the study of animals, has a direct bearing on our agricultural prosperity. Knowledge of our animal friends and foes will enable us to harness and control these tremendous zoological forces to our best purpose in order that peace and plenty may prevail in this world.

6. PROF. F. A. E. CREW, Edinburgh.

The influence of heredity on resistance to disease.

The problem of resistance to disease is of great scientific interest and also of vital practical and economic importance. It is a complex problem demanding for its attempted solution the aid of the bacteriologist, the protozoologist, the physiologist and the geneticist together with others.

The degree of resistance, ranging from immunity to extreme susceptibility, depends upon a multiplicity of factors which may be grouped under the headings: environment, function, and inheritance.

The evidence in favour of inherited predisposition to or relative immunity from disease is overwhelming, but the relative importance of heredity, function, and environment still remains an unsolved problem.

[The author could not attend this meeting.]

7. DR. B. SUNDARA RAJ, Madras.

Fisheries—the Problem of Food Supply in India.

The health of a nation is its greatest asset and the foundation of all health is a sufficient and properly balanced diet. It is now being emphasized on every hand that the diet of the average villager is neither sufficient nor balanced, and scientific data is becoming increasingly available to prove exactly where and how the diet of the masses is deficient.[1] The field enquiries so far made of groups of families show that according to the standard accepted for the average requirements of a manual worker in the Tropics, even villagers who are a little better off than the poorest classes of cultivators are underfed,[2] and most of the latter have accustomed themselves to a state of semi-starvation.

Even worse from the physiological point of view than the insufficient diet of the masses is the lack of essential food factors in the food that is taken. These are protein, fat, and Vitamin A. Such protein as is obtainable at present by the villagers is usually vegetable protein of poor biological value.[3] The Expert Commission of the League of Nations on Nutrition has reported that 'during growth, pregnancy and lactation,

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[1] Press Communique—Director of Public Information, dated 5-4-1937.

[2] Ceylon Journal of Science, Vol. IV, Part I, dated 21-4-1936, and Dr. Aykroyd and Mr. B. G. Krishnan 'Diet Surveys in S. Indian Villages'; Indian Journal of Medical Research, Vol. XXIV, No. III, January 1937, pp. 671–673.

[3] *Ibid.*, p. 679.

some animal protein is essential and in the growing period it should form a large proportion of the total protein'. Dr. Aykroyd has found that in devising cheap balanced diets in India, the inclusion of animal protein in adequate amounts is the point which presents the greatest difficulty.[1]

The sources of animal protein are milk, eggs, meat and fish. Milk is the most valuable food known, yet it has been calculated that for the Madras Presidency only 3·6 oz. per head per day is available from cows, buffaloes and goats combined.[2] In point of fact the great majority of poor families consume no milk products at all.

Meat.—India has more than a quarter of the cattle of the whole world—in fact they have been calculated to number 2 for every three of the population—yet their milk yield as we have seen is negligible and their flesh is forbidden as an article of food to Hindus. Beef and pork therefore are used by only small sections of the population. There remains mutton from sheep and goats—poultry is negligible—of which the available supply has been calculated for the meat eating population of the Madras Presidency at hardly ·6 grammes of protein daily.

Fish.—The prime source of fish is the sea, but apart from a negligible amount sent inland in ice for a few well-to-do customers the consumption of fresh sea-fish is confined to a narrow belt of country 10–15 miles wide along the Coast which can be reached by runners, and possibly 50–60 miles from the Coast where bus traffic exists. But in the inland areas, where animal protein from other sources is in such serious defect, fresh fish, except what can occasionally be obtained from tanks and rivers, is altogether unprocurable. Cured fish, of which a limited amount is available, loses some of its most valuable qualities during the process of curing, especially by the methods usually practised in India.

The statistics of consumption for a coastal town are available [3] and make interesting reading. Madras City, which had in 1922 a population of 527,000, was found as the result of a daily market enquiry to consume about 9½ lbs. of fresh fish per head per annum, taking only 80% of the population as fish-eaters. This means that in a city actually situated on the Coast and containing a large proportion of people living in European style, many of whom take fish daily, and also a much greater number of people whose standard of living is certainly above that of the average villager, the average daily consumption of fish per head is only ½ oz. It can therefore be safely assumed that as a source of protein to the underfed masses in the great inland areas fish is practically unknown.[4] So much for protein. The next serious deficit in Indian diet is its low fat content and in consequence the virtual absence of Vitamin A. According to Dr. Aykroyd the daily amount of fat necessary is 1½ to 2 oz. or 40 to 60 g.[5] The survey showed an average of only 4·4 g. daily for poor families and 26·9 g. if well-to-do ones were included.[6] Fat in itself is a necessary article of diet, while the absence or deficiency of fat-soluble Vitamin A is the source of much of the general low standard of vitality found every where as well as the prime cause of widely prevalent diseases such as Keratomalacia, Kerophthalmia and certain skin diseases. No Indian

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[1] Health Bulletin No. 23, The Nutritional Value of Indian Foods and the Planning of satisfactory diets by Dr. Aykroyd, 1937.

[2] Imperial Council of Agricultural Research Report 'Review of the position of dairying and the development of Dairy Industries in India', 1936.

[3] Madras Fisheries Bulletin, Vol. XV, No. 6. A statistical account of the Fish Supply of Madras. S. T. Moses. 1922.

[4] Indian Journal of Medical Research, Vol. XXIV, No. 3, p. 679 and Vol. XXV, p. 5, 1937.

[5] Health Bulletin No. XXIII, 1937, p. 5.

[6] Indian Journal of Medical Research, Vol. XXIV, No. 3, pp. 671–672, 1937.

vegetable oil contains Vitamin A but animal fats such as butter and ghee, and particularly fish liver oils are rich in Vitamin A. As we have seen, these are precisely the elements in the food supply that are so lamentably defective over the greater part of the population, especially of inland areas.

The population of India is rapidly growing. The birth rate is computed to be double the death rate and in another 3 years the total population is likely to reach 400 millions. The only important food industry in the country is agriculture, but the total area under food crop only amounts to ·72 acre per head,[1] and the production of food from this, even with improved methods and materials, cannot quickly or completely make up the serious discrepancy between population and food supply. The importation of food is precluded by the poverty of the masses.

We are therefore driven to the conclusion that some new source of food supply must be found, and that this supply must be particularly rich in protein, fat and Vitamin A. In Indian fisheries we have a source of food supply capable of immediate and immense expansion, and what is of the greatest importance, able to supply cheaply and abundantly just those factors that are so seriously lacking in the unbalanced diet of the masses of the people. At least 80% of the population will eat fish.[2] There seems to be no objection from any section of the community to fish oil as medicine. The Indian coast line gives us some 4,800 miles of access to wide seas practically unfished. At present regular fishing is only carried on by primitive methods over the greater part of the coast line, but fairly accurate statistics are available of fish landed on the Malabar Coast of the Madras Presidency. The average catch per sq. mile works out at 98·8 tons,[3] and on this basis the possible production of the sea up to the 100 fathom line, which trawling experiments have shown to be the most productive,[4] should amount to 120,000,000 tons. When fully exploited, therefore, the sea fisheries of India, excluding Burma, should be able to provide 37½ g. of protein per head daily. This will more than make good the deficiency of 29·9 g. of protein in the diet of the poorest classes as recorded by Dr. Aykroyd, and it will be protein of the greatest biological value. The fat content of the diet will also be considerably augmented if the amount of 131⅓ lbs. of fish annually per head of the population becomes available by proper exploitation, conservation and distribution of the harvest of the sea.

The deficiency of Vitamin A which in the average diet is responsible for so much suffering and economic loss among the villagers, will at once be made good by the addition of fish or fish oil to the food. Cod liver oil has long been recognized as a valuable source of this essential food factor, but the oil of the Indian skate has been found to be just as potent in value; the richest known source of Vitamin A is halibut liver oil, but in spite of crude methods of preparation, it has been proved that Indian shark liver oil has nearly half the Vitamin A potency of halibut liver oil.[5] That is to say, in Indian shark oil we have a potency of Vitamin A equal

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[1] Annual Report of the Public Health Commissioner for India for 1933.

[2] The Census Report of 1931.

[3] Madras Fisheries Bulletin: Fish Statistics from 1925-26 to 1930-31.

[4] Collection of papers dealing with the Fisheries Survey of the Bay of Bengal—Calcutta, 1911;

Report on the work of the S.T. 'William Carrick', Department of Industries, Bombay, 1923; and

A Preliminary Report on the possibilities of Commercial Trawling in the Sea around Ceylon—Ceylon Journal of Science, Section C—Fisheries, Vol. II, 1926, pp. 1–166.

[5] Annual Administration Reports of the Madras Fisheries Department—1935-36, Paras 79 and 80; 1936-37, Para 92.

to ten times of cod liver oil. Even Malabar sardine oil, which could easily be made both abundant and cheap, has been found where properly prepared to contain a quarter the Vitamin value of the best imported cod liver oil.

In his Presidential address to the Agricultural Section last year Mr. Viswanath estimated the total output of food nitrogen from all classes of crops in India at only ⅔rds of the actual requirements of the population.[1] Indian fisheries potentially offers an enormous and hardly exploited source of food supply which concerns the bulk of the population and which if developed will go far to revolutionize the diet of the masses besides conferring on the people other attendant benefits of increased wealth and occupation and may form a training ground for the future Indian Navy and Mercantile Marine.

8. Prof. W. M. Tattersall, Cardiff.

The development of the commercial fisheries of India as a source of food supply, so ably advocated by Dr. Sundara Raj, is to be whole-heartedly commended. If, however, it is to be successfully accomplished it should be done on strictly scientific lines from the commencement. The great need of India to-day is the establishment of a fishery department for all India, such a carefully planned programme of Scientific research into fishery problems, covering a long period of years designed to co-ordinate and develop the commercial fisheries of the whole country. The marked success which has attended scientific research into fishery problem in Europe during the last thirty years deserves careful study by those who are interested in the development of Indian fisheries. Such success had as a basic, purely scientific zoological studies on the plankton and on the scales of fishes, but these studies had been found to be of enormous value when applied to fishery problems, for instance, as a result of such work it is now possible to forecast, not only the yield of the herring fishery in any particular season, but also to indicate the areas which can be fished most profitably. This forecasting of the herring fishery had enabled the industry to plan its work on economic lines with a definite saving of time, labour and money. The precise methods of research, so successful in Europe, may not be strictly applicable to Indian conditions and problems, but the lessons of carefully planned research and its results should be carefully studied and taken to heart. It should not be difficult to modify and adapt European methods to the distinctive problems of India. If the fisheries of India are exploited solely from the commercial aspect, without regard to the scientific principles which should be their fundamental basis, there would be grave danger of the fisheries being ruined in the end. The problems of overfishing and close seasons especially require to be borne in mind and the lessons to be learned from earlier disregard of these aspects of the fisheries in Europe carefully noted.

9. Col. A. Olver, Mukteswar.

I have prepared no paper for this meeting but there are a few remarks I would like to make in regard to what has fallen from previous speakers. I feel that the most important aspect of an Husbandry in India at present is the nutritional aspect as it concerns the human race and I am very much in sympathy with the Director of fisheries who has drawn attention to the importance of fish as a source of first class protein and vitamins in which Indian diet is so lacking.

The development of Fisheries is not a subject with which we of the I.C. of A.R. are directly concerned except as regards inland fisheries but realizing that something ought to be done we have endeavoured as far as

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[1] Proceedings of the Indian Science Congress, 1937, p. 354.

possible to foster the development of sea fisheries which you have heard could furnish an immense supply of most valuable food.

Then there were a few points regarding the supply of milk to which he would like to refer. It had been said that in Madras the consumption of dairy products of all kinds per head per day did not amount to more than about the equivalent of roughly 3 oz. per day, while surveys carried out by the I.C. of A.R., the marketing survey and Major Gen. Megaw had shown that the average for the whole of India amounted to about 7 oz. per diem. This was far too low particularly for a population which is predominantly vegetarian and there was no reason why it should not be greatly increased. It was commonly said that Indian cows were hopelessly bad milk producers but they had been able to prove that this assumption is quite incorrect. Figures which had been obtained by the investigation carried out by the animal Husbandry Bureau of the I.C. of A.R. had shown that if properly fed and managed selected Indian cows could hold their own quite well as milk and butter fat producers. In fact there were now several herds of pure bred Indian milk cattle which even under Indian conditions had reached a higher milk yield than the average of dairy herds in Europe and America. Moreover the average butter fat content of milk of Indian cows was nearly 5% while that of most European breeds was between 3·2% and 3·7%. This investigation had also shown that by proper feeding and management the milk yield of Indian cows could be greatly increased. Ordinarily Indian cows were very badly fed from birth. Only when they were giving milk did they receive anything to supplement what they could pick up and their milk yield was hopelessly low but investigation had shown that the average yield of the same cows under good but not excessive feeding and proper management had all over India been increased by an average of 64%.

Buffaloes had been more carefully bred and fed for milk production and there was not the same scope for further improvement in their case but there was no reason why much better use should not be made of cattle to increase the yield from the land. At present too much attention was paid in India to the production of food crops but if more fodder crops were produced and the cattle better fed on the cultivated lands they could easily increase the yield from crops so that more milk and better cattle would be produced and the return per acre greatly increased.

Looking from the purely zoological point of view he was greatly concerned in the improvement of live stock of all kinds and the main factors in this work were disease control, careful selective breeding, better feeding and to make the most out of live stock it was necessary to make a careful study of existing breeds particularly of cattle. The so-called Indian Cattle were derived from a number of distinct types.

10. SIR FREDERICK HOBDAY, London.

I am pleased to be allowed to-day to add my testimony to the value of a meeting like this where the title expresses the importance of working together as a team; and your title is 'the relation of Zoology to Medicine, Veterinary science, Entomology and Agriculture'. Every branch of zoology is of importance to give assistance in the fight against disease and in none more than in the aid it can give to animals—not only in the '*cure*' but (which is of ever more importance) the '*prevention*' of diseases. Agriculture is the backbone of every country and its framework is made up of the produce of its arable land and its animals—in about equal proportions. The wealth of the owner of the animals depends upon the health of the animals—and the health of the animals *must* depend on the man who devotes his life to the study of their diseases and their prevention—i.e., the duly qualified and scientific veterinary surgeon Sir Arther Olver has spoken of the importance of the study of nutritional diseases to the growth and health of young stock. I wish to emphasize this and to say at this point how very important is the help of the zoologist—whether

he is a specialist in helminthology, Entomology or any other branch of this science. The zoologist studies and works out the life-history and in collaboration with the veterinary practitioner and together they endeavour to discover the place in the life-history of the parasite where the link of the chain can most effectively be snapped.

Your scientists of India have been so hospitable to us that we all hope to be here again at your next jubilee!—and again let me say what great pleasure it has given me personally to be allowed the privileges to spend in this section this afternoon.

11. Prof. G. D. Hale Carpenter, Oxford.

The diseases known as Trypanosomiasis in Africa afford the best example of the interrelation of animals and man. The tse-tse fly disease of S. Africa known to Livingstone and considered by him to be due to some unknown living organism injected into cattle and horses by *Glossina morsitans* was shown by Bruce to be due to a flagellate protozoon, *Trypansome brucei,* derived by the fly from wild animals. When a serious epidemic disease (Sleeping sickness) on the coasts of Lake Victoria in Africa destroyed hundreds of thousands of natives at the end of the 19th century it was shown to be due to an another species of Trypansome. Here the disease and its causal organism were known first: the carrier had to be found. It was shown to be another species of tse-tse fly *Glossina palpalis,* and the analogy with S. African 'Fly disease' of cattle was completed.

12. Principal B. L. Bhatia.

Dr. B. L. Bhatia who started teaching Zoology more than 30 years ago, felt delight in seeing that now there were a number of zoologists who have specialized in Protozoology, Helminthology, and Entomology, and that the Medical and Veterinary Departments were now no longer averse to making use of their services. He further stressed the need of the discoveries of science being made known to the general public, as the general public seem to be under the impression that the cost of scientific research is out of proportion to the benefit that is actually derived by the people. Hence the need for greater publicity and closer co-operation of the public.

XXVII. A NATIONAL HERBARIUM FOR INDIA.

(Section of Botany, in co-operation with the Indian Botanical Society.)

After a few introductory remarks, Prof. B. Sahni requested Prof. S. P. Agharkar to open the discussion.

1. Prof. S. P. Agharkar, Calcutta.

Opening Remarks.

By a national herbarium I understand a collection of plants which is fully representative of the species including all their varieties, forms, hybrids, geographical races, etc. found within the country and its adjacent parts and which includes as many types and co-types of these as possible. Each species should be represented from as large a number of localities

and as many types of habitats as possible, so as to afford a complete picture of its distribution and ecology. It should include further all plants cultivated in the country either as food crops for man and beast, raw materials for industry, medicinal drugs, or as ornamental plants. In short, it should include a complete representation of the wild and cultivated plants of the country and their variations.

Such a collection is needed not only for the use of Botanists, but also for Foresters and Agriculturists as well. Its importance for the preparation of local and provincial floras, which are absolutely necessary for the spread of a knowledge of plants among the people and inculcate in them habits of accurate observation is very great. Problems of geographical distribution of plants and their ecology can only be studied with the help of such collections.

The National Herbarium should be associated with a botanical garden (or gardens) for the cultivation of as many species as possible. This will make it possible to study the plants in a living condition, and note the range of their variation.

In order to find out the material that is available in India I wrote to the heads of various Indian herbaria for information regarding the (1) origin and history of their institution, (2) the collections included therein, (3) the staff, (4) library, (5) exploration grant and any other features of interest. From the replies received, it becomes evident that no institution in India can be said to satisfy completely the requirements of a National Herbarium.

The nearest approach to it is the Sibpur Herbarium which could be converted into the national herbarium, if appropriate means are chosen, within a comparatively short space of time and without unduly large expenditure of money. The Sibpur Herbarium contains more than two million sheets and includes a large number of duplicates of some of the earlier Indian Collections.

A detailed account of the collections available in the Sibpur Herbarium is given in T. Thomson's paper ' Notes on the herbarium of the Calcutta Botanic Garden, etc. ' published in the Journal of the Asiatic Society of Bengal, Vol. XXV (1856), pp. 405–418. A further account of the Indian collections is given by Sir George King in his address to the Botany section of the British Association at the Dover meeting in 1899 on ' A sketch of the history of Indian Botany '.

The Royal Botanic Gardens, Sibpur, in which the Herbarium is situated, and the Lloyd Botanic Gardens, Darjeeling, afford necessary facilities for the study of living plants.

Another Institution which deserves mention in this connection is the herbarium of the Imperial Research Institute, Dehra Dun. R. N. Parker in Bulletin No. 73 (1931) of the Imperial Forest Research Institute ' The Herbarium of the Forest Research Institute ' has given an account of the collections included in the Dehra Dun herbarium. Mr. Parkinson has also contributed a paper on this subject for this discussion. Notices of other Indian herbaria have been given in the papers which have been contributed for this discussion.

Unfortunately very few of the earlier collections, on which the descriptions of Indian plants are based, are now available in India. They are to be found in various British and European herbaria, the most important of which are those of the Royal Botanic Garden, Kew, and the British Museum. An account of the collections at Kew is contained in the paper which has been contributed for this discussion by Sir Arthur Hill. An account of the Indian collections in the British Museum is to be found in Sir G. King's address referred to above. Prof. A. B. Rendle, who has been keeper of the Department of Botany of this institution, and who is with us to-day, will I hope supplement these remarks. Besides these, considerable collections of Indian plants are found in many European herbaria, an account of which is found in de Candolle's Phytographie (1880).

It is useless to speculate regarding the causes which may have led to this result. The fact that nearly all the workers engaged in the Scientific study of Indian plants in those days were Europeans may have had something to do with it. As collaboration with European botanists and comparison with specimens in European Herbaria was necessary for the purpose, most of the collections were taken to Europe for study. A very large part of these, including types of new species have remained in European institutions and only a small part has been returned to India. The absence of any rules, until recently (July, 1937), for the loan, gift or exchange of specimens from the Sibpur Herbarium may have facilitated this.

Distribution of duplicates also was principally confined to European herbaria. The most glaring instance of the omission of Indian herbaria from distribution of Indian plants was the distribution of sets of Wallichian collections, of which no complete set is available in India.

It has thus come about that most of the types of Indian species are found in European herbaria. An unfortunate consequence of this has been that no critical work on Indian plants can be done in India and Indian herbaria have become mainly agencies for the collection of plants for Kew and other non-Indian institutions.

The purpose of this discussion is to suggest ways and means to remedy this situation by the establishment of a National Herbarium and thus make it possible for work on Indian plants being done in India. The absence of types of Indian species from Indian herbaria has already been referred to above. An effort should, therefore, be made to acquire as many types and co-types of these as possible for Sibpur. In cases where it may not be possible to acquire these, specimens should be collected from the original localities—where these can be ascertained—and made into secondary types after matching them with the originals and supplemented by their photographs. In this way a collection will be built up in course of time which will be sufficient for nearly all purposes.

Acquisition of types or co-types is, however, not sufficient by itself to serve the purpose. The institution must also be adequately staffed so that the collections will be properly cared for and made available for scientific investigations.

The present scientific staff of the Sibpur Herbarium consists of the Superintendent and the Curator appointed by the Government of Bengal and one Systematic Assistant appointed by the Government of India. The Superintendent being also the administrative officer for the Royal Botanic Gardens, and Lloyd Botanic Gardens, can only devote a part of his time to this work.

It is obvious that this staff is insufficient if we expect original scientific work from them, and that it is necessary to strengthen it. The least that could be done would be to restore the post of second Systematic Assistant which was retrenched by the Government of India as a measure of economy in 1932. It is further necessary to obtain the co-operation of members of the staff of Indian Universities in working out the collections and in conducting a botanical survey of parts of the country which have not yet been explored. It will be necessary to provide for grants for exploration work both by the herbarium and University staff. It will also be necessary to depute members of the herbarium and university staff to Kew as Liaison officers for periods of 2-3 years each during which they will be able to acquire a knowledge of the collections at Kew and elsewhere.

This can easily be done without extra expenditure if the existing provision for the Assistant for India at Kew is utilized for this purpose.

It is, perhaps, not generally known that India has maintained out of its revenues, the post of an Assistant on the Staff of the Kew Gardens since 1883. This official has, nearly always, been a retired official who has never served in India after the period of his appointment at Kew. The knowledge and experience that he gained at Kew has thus not been

directly available to India. If on the other hand, the assistant for India is chosen from the staff of the Universities as suggested above, we shall soon be able to have a number of Botanists in India with a knowledge of the Indian collections in Europe who could be entrusted to work out Indian collections. The teaching of Systematic Botany in Indian Universities will also markedly improve by this measure.

I made this suggestion at the last Imperial Botanical Conference held in London in 1935. I am glad to say that Sir Arthur Hill, Director of the Kew Gardens, who is with us to-day, has recently proposed to the Secretary of State for India that this method be adopted in future for the appointment of the Assistant for India at Kew. I hope the Government of India will be able to accept this proposal, which is likely to be of immense benefit to India.

Another subject which is likely to be raised in the course of this discussion is a reorganization of the Botanical Survey of India. Prof. Bharucha, of the Royal Institute of Science, Bombay, I understand, wishes to raise this question and press for the constitution of provincial Botanical Surveys.

The present moment may perhaps be regarded as opportune for this discussion as the Director of the Botanical Survey of India has gone on leave preparatory to retirement and no announcement has yet been made regarding his successor. From the arrangements announced so far, it appears that it is proposed to distribute the duties hitherto performed by the Director among three officers, viz. (1) the Superintendent of the Royal Botanic Gardens, (2) Curator of the Industrial section of the Indian Museum, and (3) Superintendent of the Cinchona department, the post of Director of the Botanical Survey itself being kept in abeyance.

The Botanical Survey of India was constituted by the Secretary of State for India in 1885 in order to bring the various provincial Botanical departments into communication with one another. There were four such provincial departments: (1) the Royal Botanical Gardens, Sibpur, (2) the Government Botanist's department, Madras, (3) the Botany Department of the College of Science, Poona and (4) the Botany Department of Northern India at Saharanpur. Three of the provincial departments have now practically ceased to exist.

The Botany Department for Western India, which was attached to the College of Science, Poona, was transferred to the Agricultural College, Poona, on its establishment, and placed in charge of the Economic Botanist to the Bombay Government. One of the assistants of the Economic Botanist looks after the herbarium, there being no arrangement for exploration or upkeep. Purely scientific work is not now being done.

The Madras department has also suffered a similar fate. The post of Government Botanist continues to be kept in abeyance since Mr. Barber, the last holder of the post, was appointed Imperial Sugarcane Specialist. The papers by Mr. Cherian Jacob on the Madras Herbarium and by Dr. F. H. Gravely on the herbarium of the Government museum give an account of these herbaria.

On the abolition of the Northern India Botany Department, its herbarium was transferred to Dehra Dun and on the opening of the new Forest Research Institute in 1909 was amalgamated with the Forest School Herbarium. Mr. Parkinson has contributed an account of this herbarium for this discussion.

Under these conditions it is not surprising that comparatively a small amount of scientific work is being produced by officers of the Botanical Survey.

It is on the other hand gratifying to note that an increasingly larger amount of work is being produced in the Universities, in most of which facilities for research work are available. Some of the Universities have also herbaria attached to their departments, accounts of some of which are found in the communications received for this discussion.

It is, therefore, necessary to associate them more closely with the

work of the Botanical Survey by the provision of exploration grants and facilities for the deputation of members of their staff to Europe for studying the Indian collections available in those countries.

Ladies and gentlemen, I do not wish to detain you further, and request you to express your views on the subject so that a practical scheme can be elaborated for consideration by the proper authorities.

2. Mr. C. C. Calder, Sibpur, Calcutta.

The Herbarium of the Royal Botanical Gardens, Sibpur.

The present collections of the Herbarium date from the 18th century. They consist of plants contributed by almost every worker at Botany in India since, and of contributions from Botanists in Europe. It is first and foremost an Indian Herbarium. It contains a fair amount of foreign collections of S.E. Asia, Japan, Persia, Asia Minor, Europe, Africa and America. Invaluable contributions have been received in exchange from the Director of Kew, Sir William Hooker and his son and successor Sir Joseph Hooker. Interchanges with many botanical institutions both in Europe, Asia, India and America have materially enriched the herbarium in the exotic collection. Amongst the private contributors in past times, who have enriched the herbarium collections by their donations, mention must be made of Vicary, Edgeworth, Griffith, Wight, Simons, Law, Gibson, Stocks, Dalzell, Kurz, Miquel, Jenkins, Maingay, Rottler, Heyne and Klein. Amongst contributors in later times may be mentioned Kurz, Scully, Aitchinson, Duthie, Beddome, C. B. Clarke, J. S. Gamble, Brandis, King, Anderson, Falconer, Maclelland, Mann, Fisher, Fischer, Kanjilal (Senior), Collett, Sir J. D. Hooker, J. G. Wood, Rev. J. Campbell, Watt, Burkill, Cave, Pantling, Gammie, W. W. Smith, Craib, Garden collectors and Botanical Survey collectors since 1890.

The superior staff consists of the Superintendent of the Garden and the Curator of the Herbarium.

The Library consists of 22,500 volumes of books and journals arranged systematically under subject and regional heads with alphabetical card index of authors. They are mostly on Taxonomy of plants.

Roxburgh's unpublished drawings running to several volumes and the manuscript catalogue of Wallichian sheets, also unpublished, are features of interest.

3. Mr. C. E. Parkinson, Dehra Dun.

The Herbarium of the Forest Research Institute, Dehra Dun.

The herbarium of the Forest Research Institute at Dehra Dun was started by Mr. J. S. Gamble of the Indian Forest Service who became the Director of the Forest School in 1890. To start the collection he presented the herbarium with a duplicate set of his own collections that he made in Bengal and Madras and he added to it by collecting assiduously during his stay in Dehra Dun and from the contributions that he received from various forest officers whom he had doubtless interested in botanical work. Gamble collected exotic plants which are so frequently neglected by collectors and many of these are of interest in that they show the date of introduction and source of many of the bamboos and other plants grown in the Forest Park and grounds of the Forest School at Dehra Dun. Mr. J. F. Duthie of the Botanical Department of Northern India contributed largely to the Forest School herbarium and good local collections of trees and shrubs were obtained by the Instructors and students of the school, especially from Upendranath Kanjilal and Mian Birbal. Several private collections made by forest officers appear to have been presented for instance by A. Smythies from the Central Provinces, Gustav

Mann from Assam, A. Lowrie from Ajmer, J. C. McDonell from Kashmir and R. Ellis from Chamba. By exchange a number of Australian plants were received from Baron von Mueller.

The herbarium was originally housed in one of the buildings belonging to the Forest School, now the Forest Rangers' College in Dehra Dun, and it became part of the Forest Research Institute in the course of its development. In 1908 the herbarium of the Botanical Department of Northern India was transferred from Saharanpur to Dehra Dun and with the opening of the new Forest Research Institute at Chandbagh it was amalgamated with the Forest School herbarium in 1909 and housed with the Forest Botanist's office in a separate building in the Chandbagh estate north of the main Institute building. Nothing is known of the relative sizes of these two herbaria except that the Saharanpur herbarium was larger than that of the Forest School. A note on the origin and development of the Saharanpur herbarium up to the time of its transfer and amalgamation with the Dehra Dun herbarium will be of interest.

The Botanical Gardens at Saharanpur were established in 1816 but no proper herbarium was formed till many years later. Dr. Govan, the first Superintendent, collected plants in the Sirmoor State in the Simla hills and part, or possibly the whole of his collections, which have since not been traced, were listed in Wallich's Catalogue. He was succeeded by Dr. Royle, well known for his 'Illustrations of the Botany of the Himalaya mountains' published between the years 1833 and 1840. Royle, during botanical explorations in the Doon and the hills north of the Doon and the Simla hills, made a collection of herbarium specimens, the bulk of which he took with him on retirement to England and were sold after his death in London for a few shillings, but some that he left behind were preserved in the Saharanpur herbarium. Dr. Falconer succeeded Royle in 1831 and the collections that he made or obtained from various parts of India were mainly sent to London but some have been preserved in the Saharanpur herbarium. Dr. Jameson who succeeded Falconer in 1842 made few collections of interest.

Mr. J. F. Duthie succeeded Dr. Jameson in 1876 as Superintendent of the Botanical Garden and in 1887 he became the Director of the Botanical Department of Northern India and from that year up till his retirement in 1902, was able to devote his time entirely to Botanical work. Prior to his arrival the herbarium occupied a very subordinate position at Saharanpur but he immediately set to work to put what there was of it in order and during his botanical tours he collected extensively and added several thousands of specimens to the herbarium. He also obtained valuable material by interesting civil and military officers in collecting and through the authorities of the Royal Botanic Gardens, Kew, and his two collectors Inayat Khan and Harsukh who toured many parts of India and became efficient and experienced collectors. Duthie can be regarded as the founder of the Saharanpur herbarium.

Duthie made the following special hot weather tours for botanical exploration and collection and the specimens obtained by him during these tours were incorporated in the herbarium :—

1877 to Jumnotri and the source of Jumna.
1879 to the Kedarkanta mountain in Tehri Garhwal.
1881 to Gangotri and the head of the Bhagirathi valley.
1883 to Gangotri, the Nila valley and across to Jumnotri.
1884 to Kumaon, West Nepal and the Tibet frontier.
1885 to British Garhwal as far as the Kuari pass.
1886 to Kumaon and West Nepal.
1892 to Kashmir and via Baltistan to Gilgit.
1893 to Kashmir via the Liddar and Sind valleys to Baltistan, across the Kargeh Pass and along the Kishenganga valley to Gurais and thence to the Deosai Plains by the Burzil Pass.

In addition Duthie visited several localities in the United Provinces, Rajputana, the Central Provinces and the Punjab and accompanied the students of the Forest School, Dehra Dun, on their tours in the Siwaliks, Dehra Dun, Jaunsar and Garhwal. He also accompanied the Black Mountain Military Expedition in 1888 and Inayat Khan and Harsukh, his collectors, accompanied the Chitral Expedition in 1895. Harsukh also made interesting collections in Gilgit and Waziristan.

As far as is known none of Roxburgh's specimens are represented in the Dehra Dun herbarium but there are a number of specimens collected in the Royal Botanic Gardens, Calcutta, which bear a label similar to those commonly found in the Wallich Herbarium and which are sometimes of great value in helping to determine some of Roxburgh's plants.

Many of the older collections made for the Calcutta Botanic Garden prior to 1842 are also in this herbarium. A few of Wallich's Nepal plants were recently received from the British Museum and others, occasionally bearing the Catalogue numbers, have been received either from Calcutta or from private collections such as that of Sir George King. There are also some specimens of Strachey and Winterbottom, Griffith, Helfer and Hooker f. and Thomson and a fair number of Stocks' specimens have come in with the Herbarium of Dalzell which was purchased jointly by Duthie and King. A set of Wight's South Indian specimens were received from Kew but it was not a complete one and more of his specimens have come with the herbarium of Dalzell. Some specimens of the earlier collectors like T. Thomson, Beddome and Falconer may also be seen in the herbarium and the following collections of the later collectors may be mentioned as being specially valuable and extensive :—

Col. Davidson, R.E., from Kumaon.

Dr. Aitchison, a complete collection of his Punjab plants. A nearly complete set of his Kurram valley specimens. A set of his Afghan Boundary Delimitation specimens.

Dr. Goodenough, this herbarium was received from Kew and contains specimens from countries other than India.

Sir D. Brandis, the greater portion of Brandis' herbarium was received from Kew.

Thwaites, a valuable collection of Ceylon plants.

C. B. Clarke, The Cyperaceæ and other specimens from various parts of India.

Sir H. Collett, from Simla, North-West Frontier and Upper Burma.

C. F. Elliott, Conservator of Forests, Punjab. Specimens from the Punjab and North-West Frontier.

A. V. Munro, from Hazara, Baluchistan and Multan.

C. W. Hope contributed many specimens of ferns.

W. Gollan, Superintendent of the Botanic Gardens, Saharanpur, from 1887 to 1904 collected extensively. He was mainly interested in mosses.

Cooke, an extensive collection of Bombay plants labelled 'College of Science Poona' was received from Dr. Cooke.

Lisboa, grasses collected by Dr. Lisboa are frequently mentioned in the Flora of British India.

Gamble, from Bengal and later from Madras.

W. A. Talbot, Conservator of Forests, Bombay, contributed specimens from the Bombay Presidency.

J. H. Lace, from Baluchistan and the Punjab and later extensive collections from Burma which were supplemented by collections made there by various forest officers whom he interested in his work, like E. M. Buchanan and Maung Kyaw.

H. H. Haines, from the United Provinces, Bengal, Bihar and Orissa and the Central Provinces, collections made in connection with his 'Botany of Bihar and Orissa' and 'Forest Flora of Chota Nagpur'.

D. O. Witt, in preparing his Descriptive List of the Northern and Berar Forest Circles, Central Provinces, contributed collections.

R. S. Hole, collections made during his tours as Forest Botanist in Assam, the Central Provinces, Mussoorie and Jaunsar.

A. E. Osmaston, from Dehra Dun, Ramnagar, Garhwal and extensive collections from Kumaon made for his Forest Flora of that area.

R. N. Parker, extensive collections from the Punjab, Chamba, Almora and Burma during the many tours made by him and numerous collections made during his stay in Dehra Dun.

Rai Bahadur Upendranath Kanjilal, extensive collections from Assam and Dehra Dun.

C. E. Parkinson, from the Andaman islands, Burma, Kulu, Jaunsar, Bengal and Chittagong.

H. G. Champion, from Almora and various parts of India during tours made by him as Silviculturist of the Forest Research Institute.

Dr. N. L. Bor, collections from Assam, Naga hills.

Numerous minor collections have also been received from the various provinces in India and from Burma from forest officers and others interested in the collection of plant specimens or in connection with their work. These are too numerous to detail here but the following deserve mention. From the Andaman islands collections made by B. B. Osmaston, R. L. Heinig, C. G. Rogers, King and Prain and their collectors ; from Burma collections were sent in by C. B. Smales, C. G. Rogers, A. Rodger, especially Dipterocarps, and duplicates of the extensive collections made by the Forest Botanist and his collectors were supplied from the Maymyo herbarium. Kashmir collections came from Rai Bahadur Keshavanand and from W. J. Lambert. Specimens were sent from Coorg by H. S. Tireman and Madras collections by C. E. C. Fischer, A. W. Lushington and E. K. Krishnan. Some of Bourdillon's Travancore specimens are in the herbarium and the Conservator of Forests sent many from that State. Numerous students' collections have also been added to the herbarium as well as those made at Dehra Dun and the adjoining country by B. L. Gupta in connection with the revision of Kanjilal's Forest Flora and by M. B. Raizada in bringing Duthie's Flora of the Upper Gangetic Plain up to date.

The collections in this herbarium are not only confined to Indian specimens but numerous valuable specimens from all parts of the world have been obtained by exchange from other botanical institutions. The following are the chief additions made in this way.

Russia.—Central Asian and other plants from that country received from the Imperial Botanic Garden, St. Petersburg, later known as the Principal Botanic Garden, Leningrad.

Switzerland.—A valuable collection of plants largely material described in the Flora Orientalis was received from Dr. Boissier. Also specimens from other parts of Europe from the Botanic Gardens, Geneva.

Philippines.—Through Dr. E. D. Merrill valuable exchanges were made with the Bureau of Science, Manilla.

America.—By exchange with the Arnolds Arboretum numerous woody plants have been received including many of E. H. Wilson's Chinese collections. American plant specimens were also received from the Gray Herbarium and the New York Botanic Garden and from the latter institution a valuable collection of Dr. Koelz's North-West Himalayan plants were obtained.

Japan.—Japanese specimens from the Imperial University, Tokyo, Japan.

Sweden.—From the Botanical Gardens, Stockholm, and the State Natural History Museum Scandinavian plants including an extensive collection of Salix specimens determined by Floderus.

Australia.—From the Botanic Gardens, Sydney, and the National Herbarium, Melbourne, many Australian collections including a collection of Eucalyptus named by J. H. Maiden. Also a collection from the School of Forestry, Victoria.

South Africa.—A collection of South African plants from the National Herbarium, Pretoria.

Revision of names by specialists.—Amongst many others the collections of the following plant groups have been sent to specialists for study and naming thus adding very greatly to their value :—

Mosses.—All the older Indian sheets were named by Dr. Brotherus of Helsingfors.
Ferns.—C. W. Hope spent many weeks at Saharanpur naming the fern collection.
Characeæ by H. and J. Groves.
Aconitum by Dr. O. Stapf.
Cruciferæ by O. E. Schultz.
Impatiens by Sir J. D. Hooker.
Leguminosæ by Sir D. Prain.
Crassula some of the sheets have been named by R. Hamet.
Eucalyptus most of the species cultivated in India have been determined by J. H. Maiden.
Callistemon by E. Cheel.
Umbelliferæ the naming of the plants in this family had been taken by H. Wolff but had not been completed at the time of his death though a great many were determined by him.
Gentiana by J. H. Burkill.
Labiatæ by Sir D. Prain.
Plantago by Pilger.
Polygonum by A. T. Gage.
Euphorbia by A. T. Gage.
Ephedra by Dr. O. Stapf.
Dioscorea by Sir D. Prain.
Juncaceæ by G. Samuelsson.
Cyperaceæ by C. B. Clarke and W. B. Turrill.
Gramineæ by Hackel.
Bambusæ by J. S. Gamble.
Rutaceæ, Aurantioideæ by Dr. T. Tanaka.
Avicennia by Dr. H. N. Moldenke of New York.
Ixora and *Pavetta* by Dr. C. E. B. Bremekamp.
Meconopsis by Dr. F. Fedde of Berlin and G. Taylor of the British Museum.
Corydalis by Dr. F. Fedde.
Taraktogenos and *Hydnocarpus* by Dr. H. Sleumer.
Dipterocarpus by R. N. Parker.
Terminalias of the section *Pentaptera* by C. E. Parkinson.

The herbarium is housed in one of the large halls of the Forest Research Institute at Dehra Dun where there is ample accommodation for the collections and workers with room for expansion. The number of sheets is now estimated to be a quarter of a million to which about three thousand are added annually.

4. Mr. V. M. Chavan, Poona.

The Herbarium of the Economic Botanist to the Government of Bombay.

The Herbarium of the Economic Botanist's section dates back to 1880. It was started when the Agricultural classes were held in the College of Science, Poona. The valuable collection is the work mostly done by Dr. T. Cooke, Messrs. G. A. Gammie, R. K. Bhide and H. P. Paranjpe.

The collection includes :—

(*a*) All the representative flowering plants of the Bombay Presidency and some of the Cryptogams—mostly ferns.

(*b*) Specimens of flowering plants collected and contributed from different parts of India.

(*c*) A large collection made by Mr. W. A. Talbot, Conservator of Forests, Bombay Presidency.

(*d*) A small collection, by the late Mr. Jayakrishna Indraji of Kutch containing some flora of Kathiawar.

There is no special officer in charge of the Herbarium but one of the Assistants of the Economic Botanist looks after it.

The Library of the Economic Botanist section as well as the Library of the College of Agriculture, Poona, is at the disposal of the Herbarium.

There is no special grant for exploration and upkeep.

(*Note.*—The herbarium was completely destroyed by fire in May, 1902. A fresh beginning was made by Dr. T. Cooke presenting his private collection to replace the one lost by fire.—S. P. Agharkar.)

5. Dr. F. H. Gravely, Madras.

The Herbarium of the Government Museum, Madras.

The Madras Museum is the earliest botanical institution in South India. Even so early as 1878 its botanical collections were so crowded that necessity for more room began to be felt. It was at the Madras Museum that Surgeon Major G. Bidie prepared the *Flora Medica* of India. It was here that the famous collections of Wight, W. Elliot, Drew, Cleghorn, Beddome, Bidie, as also those of C. B. Clarke, Cameron, Bourdillon, Lawson and other pioneers were preserved. When C. A. Barber succeeded Lawson as Government Botanist in 1899 he moved the Government to have the herbarium transferred from the Museum to his charge at Ootacamund which was sanctioned. When Mr. Barber's head-quarters were moved to Coimbatore the herbarium was also shifted to Coimbatore.

With the popularization of botany in schools and colleges the need for a herbarium was keenly felt at Madras and a start was made again in 1920 to form a herbarium of local plants. A study collection was soon built up and an illustrated Flora of Madras City and its immediate neighbourhood was published in 1929.

The botanical gallery needed complete reorganization and this necessitated extensive collecting in South India, in which much valuable help has been received from Mr. E. Barnes, Professor of Chemistry in the Madras Christian College. Thus the beginning of a new general herbarium was made in 1921 and its specimens have been gradually increasing in number since, though of course nothing approaching finality has been reached. The staff consists of a single member, Mr. P. V. Mayuranathan, the botanical assistant who joined the Museum in 1920, with the assistance of one attender.

There is no special exploration grant, so the cost of touring has to be met from the small travelling allowance grant from which the tours of all the Scientific Assistants of the Museum have to be paid for.

The old museum library formed the nucleus around which the large and well-organized Connemara Public Library grew up in the Museum grounds. Though now primarily a public library it continues to cater for Museum needs.

6. Mr. K. Cherian Jacob, Coimbatore.

The Madras Herbarium.

The Madras Herbarium was founded in the year 1874 by Mr. M. A. Lawson, a former Principal of the Presidency College, Madras. It was

first located in that College and was subsequently transferred to Ootacamund from where it was finally brought down to Coimbatore in 1910 on account of its dry and cool climate which is very essential for the proper preservation of the specimens. Dr. C. A. Barber, C.I.E., was associated with the Herbarium from 1900–1912 and contributed much towards the excellence of its collections. Later, Dewan Bahadur K. Rangachari, M.A., and Rao Bahadur C. Tadulingam, F.L.S., added much valuable material. At present Mr. K. Cherian Jacob, L.Ag., F.L.S., is in charge of the Herbarium under the administrative control of the Principal, Agricultural College, Coimbatore.

The Herbarium now contains about 85,000 sheets of specimens a large number of them has been authenticated at the Royal Botanic Gardens, Kew, and they include many types and co-types of representative South Indian plants. The collections of many eminent Botanists like Wight, Beddome, Gamble, Bourdillon, Bourne, etc. are included in the Herbarium. There is also a separate fruit and seed collection in addition to a collection of South Indian drugs. Materials for the preparation of the Flora of the Presidency of Madras by Gamble were supplied by this Herbarium. At present, materials for the preparation of the District Floras of the Presidency are being collected. About 100 new species were described from the material available in the Herbarium. Besides these, there is a wide variety of exotic collections from Cuba, Australia, South Africa, Federated Malay States, United States of America, etc. The economic section of the Herbarium contains a set of well-prepared specimens of all the South Indian varieties of Bananas and also specimens illustrating the life-history of most of the South Indian crops.

A small Library of about 200 volumes of well-known Floras is kept in the Herbarium for ready reference. Besides this, there is the General Library of the Research Institute containing about 5,000 volumes of botanical books and forming an easy source of reference to the Herbarium staff. The wall space of the Hall of the Herbarium is decorated with framed specimens of interesting and economic plants. About 70 varieties of ripe bananas are preserved in their natural colours and exhibited along with life-cycle charts and photographs of the same.

The staff of the Herbarium now consists of Senior Assistant Mr. K. Cherian Jacob, L.Ag., F.L.S., assisted by two Sub-Assistants and a Plant Collector. The post of the Government Systematic Botanist is now kept in abeyance. The present exploration grant is Rs.450 as against the original grant of Rs.3,000 in the beginning.

A small Arboretum and a Botanic Garden attached to the Research Institute form suitable adjuncts to the Herbarium.

7. Dr. M. Mitra, New Delhi.

The Herbarium of the Imperial Mycologist.

Origin and history. The inception of the Mycological herbarium of the Imperial Agricultural Research Institute, New Delhi, was made by Dr. E. J. Butler when he was appointed as the Cryptogamic Botanist to the Government of India in 1901. In 1905, Dr. Butler was transferred to Pusa as the Imperial Mycologist, and it was here that collection on an extensive scale from India was made and to which a large number of authentic specimens from foreign countries were added. In 1936, the herbarium was transferred to New Delhi when the Institute was shifted due to the Bihar earthquake of 1934.

The herbarium was started with a view to collect and identify parasitic fungi, specially those affecting plants of economic importance, so that the fungi of this country could be compared with those of other countries, thus enabling the experience and work of other countries to be utilized properly. It was also intended that this herbarium would afford to provincial workers a ready means of identifying the fungi unknown to

them, and in co-ordinating the work done in one province with that in another.

Collections included in the Herbarium. During the last thirty-five years the Section has accumulated a valuable collection of specimens of Indian parasitic fungi and has received in exchange from foreign countries such as the Philippines, Java, Straits Settlements, and also from Australia, New Zealand, Central Europe and the U.S.A. collections of parasitic fungi of economic importance in those regions. The collection represents about 750 genera and about 5,000 species. Apart from these fully identified specimens, there is a large collection of fungi whose specific determination has not yet fully been made.

Staff. The herbarium is under the supervision of the Assistant Mycologist who is helped by a junior assistant but more staff is urgently needed.

Library. The Section has been fortunate in gradually procuring a very valuable collection and it is regarded as the best library for the Mycological literature in India. It includes all the well-known current periodicals, books, monographs and floras. There is also a valuable collection of rare books and reprints. Some of these date back to 1816.

Exploration grant. Surveys were undertaken expressly for collection of specimens for the herbarium when the Section was started. Whenever tours are undertaken for the definite purpose of the investigation and observation of specific diseases, opportunity is taken to collect specimens from that locality for the herbarium. On account of lack of funds surveys cannot be done on extensive scale.

Other features of interest. In many cases, specially in fruits and vegetables and some aquatic fungi, the specimens are pickled in jars. Stages of pleomorphic fungi obtained in cultures are also pickled in fixatives.

A part of the activity of the herbarium is the maintenance of stock cultures of many pathogenic fungi. There are at present about 300 cultures obtained from various sources and are available for mycological workers in India and foreign countries.

A catalogue of all the specimens in this herbarium and their host index was printed and made available to the mycological workers in 1921. An up-to-date supplementary list is being prepared and will soon be available.

8. DR. S. HEDAYETULLAH, Dacca.

The Herbarium of the Economic Botanist to the Government of Bengal.

Collection and identification of the plants on and round the Dacca Farm began with the creation of the Dacca Central Agricultural Farm in 1909 by Dr. G. P. Hector.

There are about 5,000 specimens. The collections included in the herbarium are :—(*a*) Weeds of the cultivated fields, (*b*) Legumes and fodder crops, (*c*) Grasses of Bengal and Bihar, (*d*) Varieties of crop plants, (*e*) Varieties of paddies, and (*f*) Disease and pest infected crop plants.

There is no exclusive staff for the herbarium, but there is one preparer who makes the herbarium sheets and takes care of the specimens. The field staff (6) of the section collect material whenever necessary. The identification of the material is done by the Economic Botanist or by his Laboratory assistants.

There are about 25 volumes of Floras of India and her provinces. There is a proposal for acquiring Index-Kewensis and Pflanzen-Familien shortly.

There is no special exploration grant, but the Economic Botanist and his staff have a total travelling allowance grant of nearly Rs.7,000. They tour throughout the province and sometimes outside the province

as well. Interesting specimens are collected from different parts of Bengal and elsewhere during the tour.

The department has in view the building of a central agricultural museum at the Dacca Farm. In this connection a proposal has been made to set apart one spacious hall for a herbarium of agricultural plants. The special feature of the proposed herbarium will be to keep complete specimens of all the pure line strains and types of the various crop plants of Bengal and if possible of other provinces as well.

The present herbarium is being reorganized and attention is being concentrated on collecting the weeds of the cultivated fields of Bengal in order to study their botany with special reference to their ecology and reproduction.

9. Mr. T. S. Sabnis, Cawnpore.

The Herbarium of the Economic Botanist (Oilseeds) to Government, United Provinces.

As far as the teaching section in Botany is concerned, there is a small collection of specimens required for instructional purposes. Regarding Research side, I have an exhaustive collection of plant types of Agricultural crops representing different parts of India as well as the new types evolved either by selection or hybridization. The collections were made from plants grown with seeds received from different parts of India. The specimens pertain to the following crops :—Sun-hemp (*Crotalaria juncea* L.), Linseed (*Linum usitatissimum* L.), Rai (*Brassica juncea* H. f. and T.), Sarson (Brassica campestris, L.), Tori (Brassica Napus, L.), Safflower (*Carthamus tinctorius* L.), Groundnut (*Arachis hypogæa* L.), Til (*Sesamum indicum* L.), Jawar (*Andropogon Sorghu* Brot), Maize (*Zea mays* L.), Bajra (*Pennisetum typhoideum* Rich), Sanwan (*Panicum Frumentaceum* Roxb.), Manduwa or Nashani (*Eleusine coracana* Gaertn), Arhar (*Cajanus indicus* Spreng), Mung (*Phaseolus radiatus* Linn.), Urd (*Phaseolus Mungo* Linn.), Bhang, Ganja or Charas plants—*Cannabis sativa* L.

There is no special grant for maintaining the herbarium, but these collections were made for reference purposes from experimental crops.

10. Mr. M. Bhatia, Nagpur.

The Herbarium of the second Economic Botanist, Government of the Central Provinces.

The herbarium was started by Dr. R. J. D. Graham in 1908 for the use of the students, staff and research workers of the Agriculture Department, and nearly all the Angiosperms, i.e. indigenous plants of Central Provinces and Berar are in its collection. There is no separate staff maintained to look after the herbarium nor is there any separate library or exploration grant sanctioned for it.

11. Dr. T. C. N. Singh, Sabour.

The Herbarium of the Economic Botanist, Sabour (Bihar).

The herbarium consists chiefly of collection of plants from Bhagalpur District. It was started by the late Mr. E. J. Woodehouse, Economic Botanist to the Government of Bihar and Orissa sometime about the year 1910.

It consists of plants belonging to Angiosperms, Pteridophytes, Fungi and Lichens, etc.

There is no special staff attached to the herbarium.

A departmental library is being maintained.

12. Mr. S. L. Ghose, Lahore.

Herbarium of the Government College, Lahore.

The Herbarium of the Government College, Lahore, was started in 1915 by the late Professor S. R. Kashyap, D.Sc. Since then valuable collections have been made by members of the College and University botanical staffs, research scholars and students of advanced classes. There is no special staff to look after the Herbarium. All the plants are housed in the Government College Botany Laboratory and are under the direct supervision of the Professor of Botany of the College, who is also the Director of the University Botany Laboratory. Some of the collections have been made with the help of occasional grants from the College and from the University.

The following collections are found in the Herbarium :—

A. (i) A very rich collection of Angiosperms from Southern Tibet especially South-Western Tibet, comprising more than 200 species (excluding Cyperaceæ and Gramineæ), all properly labelled. This is perhaps the largest collection in the world for this area. (ii) A richly representative collection of flowering plants from the outer ranges in the Western Himalayas. (iii) A comprehensive collection of flowering plants comprising about 450 species from the Lahore District, properly named. (iv) A representative collection, also named, from the rest of the Punjab plain.

B. (i) A comprehensive collection of Ferns and their allies comprising about 75 species from Mussoorie and Dehra Dun. (ii) A rich collection of Ferns and their allies comprising about 100 species from Darjeeling, together with another 50 species from Sikkim, all properly named.

C. A rich collection of mosses comprising more than 200 species from the Western Himalayas and the Punjab plain, mostly named by Prof. Dixon.

D. (i) A comprehensive and properly named collection of Liverworts from the Western Himalayas and the Punjab plain comprising about 165 species. (ii) A richly representative collection of liverworts, properly named, from Darjeeling and Sikkim comprising about 100 species. (iii) Some 40 species of liverworts from South India. (iv) About 300 species of foreign liverworts, properly named.

E. A richly representative collection of Lichens comprising about 50 species from Darjeeling and Sikkim, properly named.

F. (i) A good collection of Indian fungi, especially of those forms causing diseases of plants. (ii) A rich collection of smut fungi and aquatic moulds. (iii) A large number of specimens of fungi imported from continental Europe and America.

G. (i) A fairly representative collection of freshwater algæ of the Punjab comprising about 250 species, properly labelled. (ii) About 50 specimens of marine algæ from Karachi coast and its neighbourhood, which are being worked out.

There is a library in the Laboratory in which botanical books and journals belonging to the College, together with some of those of the University are kept. About 1,900 volumes and 4 journals are housed here. There is also a University Library at a distance of about a furlong in which a fairly large number of botanical books are kept and some leading botanical periodicals are regularly subscribed for.

At present no exploration grant is given to the Herbarium from any source. The College and the University Botany Departments are maintaining the Herbarium with difficulty from their own funds.

13. Prof. F. R. Bharucha, Bombay.

Herbarium of the Royal Institute of Science, Bombay.

The total number of plants in our herbarium is 1,993 (phanerogams only).

There is no special staff.
Exploration grant : Rs.500 per year.

14. Prof. J. H. Mitter, Allahabad.

Herbarium of the Department of Botany, Allahabad University.

The Botanical Laboratory, Allahabad, was built in 1923 and its herbarium was started soon after.

The herbarium contains mostly specimens of fungi collected from various places in India (Naini Tal, Mussoorie, Simla, Darjeeling, Murree Dalhousie, Ootacamund, Almora, Allahabad, Khandwa, Majhgawan, Jubbalpur, Jullundar, etc.). Besides these, some ferns and Angiosperms have also been collected from the above-mentioned places.

A number of fungi and Angiosperms have been received in exchange from other countries.

There is no special staff for the herbarium except a herbarium bearer. A teacher of the Department, however, arranges the specimens and looks after them.

The Library facilities are not very satisfactory. There is only a small departmental library which mostly contains the books and journals necessary for teaching purposes. Books and journals have to be borrowed from other places.

The department is getting only Rs.200 a year for plant collection which greatly restricts our activities in this direction, often enabling us to visit only localities where we can be sure of getting material for class work.

A number of new species and 5 new genera of fungi have so far been described. Unfortunately some of the best specimens were available in very limited quantity.

15. Mr. J. C. Banerji, Calcutta.

Herbarium of the Calcutta University.

The Herbarium of the Calcutta University was started in 1921 by Prof. S. P. Agharkar with the specimens collected by him during his European tour in addition to duplicates presented by the Director, Botanical Garden, Berlin-Dahlem, as its nucleus. These collections included specimens from the South-West of France, Spain, the Pyrenese mountains, the Reviera coast, North Italy, Germany and Norway. A representative collection of mosses was purchased from Vienna and subsequently added to the herbarium by Dr. P. Brühl, late University Professor of Botany of the University. This is perhaps one of the best collections of mosses in India. A comprehensive and properly labelled collection of flowering plants and ferns from Chota Nagpur was presented by the late Rev. A. Campbell. A collection of duplicates from Malay, Sikkim, Andamans, Southern India and Godavari District received from the Royal Botanic Garden, Sibpur, has also been included in the herbarium.

Valuable collections made by Prof. Agharkar from Nepal, Khasi hills, Sundribans, Simla, Darjeeling, Deoban and Mussoorie have been properly labelled and added to the herbarium. Materials for a flora of the locality are being collected and determined by Mr. J. C. Banerji, Keeper of the Herbarium, Research Scholars and Students of advanced classes. A good collection of flowering plants, chiefly from Switzerland, was made by Prof. Agharkar during his European tour in 1935.

The following works of exsiccatæ were purchased and incorporated in the herbarium :—

(1) Migula's cryptogams (Algæ, Lichens and Mosses).
(2) Hupke Herbarium cecidiologicum.

There is a separate collection of interesting Indian materials preserved in fluid for a botanical museum. Owing to absence of funds for suitable show-cases and want of space in the laboratory, the collection is not being displayed properly. A fairly representative collection of Myxophyceæ of the locality has been made and properly labelled by Mr. J. C. Banerji. A good collection of local Characeæ has been properly named and a number of marine algæ from Krusadi island and its neighbourhood are being worked out.

The Staff consists of a Keeper of the Herbarium and a Plant Collector under the supervision of the Head of the Department of Botany. There is no exploration grant at present, but specimens are collected during tours undertaken with post-graduate students. The cost of local collections is being met from the departmental funds.

There is a good Library in the Department which includes many of the standard works on Systematic Botany and on the Indian flora. Most of the leading botanical periodicals are regularly subscribed for.

A small botanic garden has been recently started in the compound of the Botany Department.

16. PROF. M. SAYEED-UD-DIN, Hyderabad.

The Herbarium in the Botany Department of the Osmania University.

Proper collection and preservation of plants was started by Prof. M. Sayeed-ud-Din in the year 1931, but owing to several handicaps the progress was very slow till 1934.

Amongst the collections included in the herbarium are the local plants numbering 2,000, plants from British India about 200 obtained from the Royal Botanic Garden, Calcutta, British plants about 150, being the private collections of Prof. M. Sayeed-ud-Din and Dr. Hasain Ali Razvi, and Californian plants numbering 200 obtained in exchange from Mr. Lewis S. Rose of California.

There is no separate staff for the herbarium. Two of the members of the staff of the Botany Department are entrusted with this work.

The Library although it contains a good number of rare and standard works on floras is still poor. It is only since 1934 that it has been possible to build up a Departmental Library. Sixteen important journals are subscribed for.

Since 1935 four hundred rupees are sanctioned annually for touring expenses.

17. MR. S. H. PRATER, Bombay.

Bombay Natural History Society, Bombay.

The Bombay Natural History Society maintains no regular Herbarium. We have however in our Museum certain collections of plants presented by W. S. Birdwood, G. M. Woodrow and Major Macpherson. The collections include (*a*) Flora of Aden; (*b*) Bombay Flora; (*c*) Ferns of Ceylon.

No special staff is maintained to look after the Herbarium. It is in the charge of Mr. C. McCann, Assistant Curator.

Works on Botany include periodical journals on Indian Botany and publications from Kew. In addition there are a limited number of works dealing with the Botany of the Oriental Region. No special grants are made for Botanical Surveys.

Many important contributions on Indian Botany have however appeared and continue to appear in the Journal of the Bombay Natural History Society.

18. Sir Arthur W. Hill, Kew.

The Indian collections at Kew, and the relations between Kew and Sibpur.

The Herbarium of the Royal Botanic Gardens at Kew was founded in 1852 on the presentation of the important botanical library and herbarium of Dr. W. A. Bromfield by his sister. Actually, from the previous year Sir William Hooker's herbarium had been available for study, but it remained his private property until his death in 1865. In 1853 with the addition of George Bentham's herbarium the Kew institution was given a start which has brought it through continual accretion to its present outstanding position.

Botanical investigation had started much earlier than this in India, at least as early as the beginning of the 17th century when Edward Bulkley was attached as Surgeon to the Madras Establishment of the East India Company, while Van Rheede was preparing his great work Hortus Malabaricus on the other coast.

Regular botanical collection, however, received a special stimulus in 1768 when John Gerard Koenig joined the Danish Medical Mission at Tranquebar. This ardent botanist not only sent considerable collections to various Botanists in Europe, such as Linnaeus, Lamarck, Roth, J. Smith, Vahl, A. P. de Candolle, but greatly influenced others to similar activity, so much so that several of his friends, including J. P. Rottler, J. G. Klein and B. Heyne, banded themselves as 'The United Brothers' for the pleasure of the study of the flora.

Many new species were based on the specimens of these collectors by the botanists mentioned and others, including Koenig himself and, after his death, by his friend Dr. William Roxburgh.

Koenig bequeathed his own herbarium to Sir Joseph Banks and eventually it reached the British Museum in London.

Roxburgh was among those who came under Koenig's influence, and he eventually became the second Superintendent of the Botanic Garden founded by Lt.-Colonel Kyd near Calcutta in 1787. Unfortunately Roxburgh's Carnatic collections were lost in an inundation. His later collections, as William Griffith has pointed out, were incorporated without distinguishing marks with others accumulated at the Calcutta Herbarium.

The whole of these were taken to England in 1828 by the then Superintendent of the Gardens, Dr. Nathaniel Wallich, with the permission of the Court of Directors of the East India Company. To this large collection were added those which had reached the East India Company's Museum in previous years from Wallich himself, as well as the collections made in the Circars by Dr. Patrick Russell; by Rottler, Klein and Heyne in other parts of South India; by Dr. Francis Buchanan-Hamilton in various parts of India; in Siam and Cochinchina by G. Finlayson and by Dr. Robert Wight in the Madras Presidency. Wallich had spent some months in Nepal and besides collecting plants himself had instructed native collectors from whom he continued to receive plants after his return to Calcutta. The whole collection, now known as the Wallich Herbarium, was entrusted to Wallich to be divided into sets and distributed. This task, with the assistance of voluntary helpers, was accomplished between the end of 1828 and 1832. The sets were transferred to various European Herbaria, the chief one being presented by the Court of Directors of the East India Company to the Linnean Society of London.

No set came to Kew, for the simple reason that the Kew Herbarium, as we have seen, was not then in existence. At the end of 1832, before his return to India, Wallich sent the unsorted remainder to the Linnean Society with a request that the best obtainable set from it should be transmitted to Calcutta. This request remained unfulfilled for some time, but some twenty years later this remainder, together with some Indian

collections made by H. Falconer, W. Griffith and H. Helfer, and others by Helfer and Maingay from Malacca, which had been lying in the cellars of East India House, were made over to Kew and, after being sorted into sets, were distributed under a *Kew Distribution number*, together with those obtained by Joseph Dalton Hooker and Thomas Thomson in their expeditions in the Himalayas a few years earlier and the collections made for them by the latter's brother, Gilbert Thomson, in S. India, in view of the projected 'Flora indica', of which only the first volume was published in 1855.

A good set of these was presented to the Herbarium of the Royal Botanic Garden at Calcutta.

I need not dwell at greater length on this aspect of the subject since a full account was given by Dr. Thomas Thomson, then Superintendent of the Calcutta Botanic Garden, in his note on the Herbarium of that institution published in 1856 in the Journal of the Asiatic Society of Bengal, Vol. XXV, p. 405.

I should also remind you of Sir George King's Address to the Botanical Section of the British Association held at Dover in 1899, when he gave a very comprehensive and most interesting account entitled 'A Sketch of the History of Indian Botany'. In this Address a full record is given of all the collectors who have enriched the Herbaria at Calcutta, at Kew and at the British Museum with Indian collections.

In 1913, owing to pressure of space, the Linnean Society of London offered the custody of its set of the Wallich Herbarium to the Kew Herbarium, where it is still housed in the fine mahogany cabinets in which it was kept at the Linnean Society; the duplicates from the remainder alluded to are incorporated in the general herbarium at Kew.

In subsequent years, further Indian material came to enrich the Kew collections in various ways; by gift, purchase or exchange. The most important of these are the collections of Strachey and Winterbottom from the Himalayas, a set of which was sent to the Calcutta Herbarium; those of M. P. Edgeworth from North India; of V. de Jacquemont obtained from French sources; of Dr. R. Wight and Colonel R. H. Beddome,[1] both mainly from South India; of J. E. T. Aitchison on the N.-W. Frontier; of Dr. B. Schmid in the Nilgiri Hills; of N. A. Dalzell and J. Stocks from Bombay; of Colonel Collett in Burma and those made by Sir D. Brandis from various parts of India and Burma. In addition, C. B. Clarke, J. S. Gamble, J. H. Lace, J. R. Drummond and H. H. Haines presented their complete herbaria to Kew, each consisting of a very large number of sheets.

Kew has received also very large contributions from the Calcutta Herbarium and to a lesser degree from the Madras Agricultural College, the Forest Research Institute at Dehra Dun, and the Forest Departments of Travancore and Burma. Besides these sources, Kew has received contributions from a number of individual botanical collectors in various parts of India and Burma. Wherever possible the Calcutta Herbarium has been supplied with duplicates of interesting or new plants from these acquisitions and the intercourse between the two establishments has been mutually helpful and cordially reciprocal, thanks to the enlightened policy of the respective Superintendents and Directors, among whom I should especially mention Sir George King, Sir Joseph Hooker, Sir William Thiselton-Dyer, Sir David Prain and Lt.-Colonel A. T. Gage.

Besides the supply of herbarium specimens, Kew has been in a position to render considerable service to Calcutta in the determination during a period of years of a very large number of sheets by comparison with the types or with well-authenticated specimens. Facilities are always offered for the study of the Kew material and the following main floras have been compiled entirely or in part in the Kew Herbarium: 'The Flora of British

[1] Beddome's first set of specimens is at the British Museum.

India' by Sir J. D. Hooker assisted by several botanists; 'The Flora of the Upper Gangetic Plain' by J. H. Duthie; 'Flora Simlensis' by Col. Sir H. Collett; 'Indian Trees' by Sir D. Brandis; 'Flora of the Presidency of Bombay' by T. Cooke; 'Flora of the Presidency of Madras' by J. S. Gamble, and the 'Botany of Bihar and Orissa' by H. H. Haines. Sir George Watt's 'Commercial Products of India', I may remind you, was also prepared at Kew.

For the purpose of the preparation of some of these works a large number of specimens were obtained on loan from the Calcutta Herbarium, the Agricultural College, Madras, and the Forest Department, Travancore. These were all scrutinized, the determinations checked and corrected whenever necessary and the undetermined ones named. Some of these, when the number of duplicates so justified, were retained with the permission of the responsible authorities, and the rest, comprising the great majority, were duly returned.

The recent visit to Kew of Mr. K. Biswas, the Curator of the Calcutta Herbarium, has been a welcome one, and with his collaboration a considerable number of sheets from the Kew Herbarium have been presented to Calcutta. Further duplicates will be set aside for Calcutta when a list of requirements has been prepared and sent to Kew. It is to be hoped that Mr. Biswas's visit will be followed by visits of other Indian Systematic Botanists and that the co-operation and friendly intercourse between our two great Institutions, which has lasted so long, with such fruitful results may become closer and of increasing value in the future.

19. Dr. F. R. Bharucha, Bombay.

A Plea for the Revival of Provincial Botanical Surveys in India.

A plea is made to establish Provincial Botanical Surveys in each of the eleven Provinces of India for the following reasons: (1) To be able to survey the vegetation of India; (2) For mapping of the vegetation which is not done so far in India; (3) For the formation of provincial, regional and local herbaria; (4) For the publication of Flora exsiccata; (5) For the collection of seeds, fruits, etc. for academic investigations of commercial value; (6) To serve as centres of special information to Medical, Chemical, and Pharmacological Institutes; (7) For propagation of knowledge for nature-study and creation of National Parks for preserving bits of natural vegetation. Lastly a few suggestions are made on the method of organization of such Surveys.

20. R. N. De, Shillong.

Shillong herbarium.

A serious effort to start a herbarium in Shillong seems to have been made from the year 1912 when Sir Archdale Earle, the then Chief Commissioner of Assam and the Government of India decided to publish a Flora for Assam. The late Rai Bahadur Upendranath Kanjilal, retired Extra-Deputy Conservator of Forests and an eminent Botanist was entrusted with the task of touring the whole province with a view to collection of plant specimens. A very comprehensive collection was made by him and it became necessary to maintain a staff for mounting and poisoning specimens.

Once a home was found for housing the specimens, collections began to come in from Forest Officers and others interested in the Flora of Assam and today there are more than 38,000 sheets and 2,000 wood specimens in the herbarium.

It would be, however, wrong to say that our collection began only from 1912, for we have got in our herbarium, sheets collected by that distinguished botanist Gustav Mann, in the year 1878.

The herbarium is now the most important centre for collection and identification of plants in Assam and receives many enquiries regarding their occurrence, supply and properties. In fact, the herbarium has more than justified its existence.

Although much useful work is being done, we are being constantly handicapped for want of adequate funds. The Botanical Forest Officer can hardly tour in the remote interior for exploration which is at present delegated to a herbarium mounter. The staff of the herbarium which consists of a Botanical Assistant on whom devolves most of the routine work, two mounters and two poisoners who are still on a temporary basis is hardly sufficient to cope with the increasing work.

No grant is earmarked for exploration, but the Conservator of Forests allots funds from time to time which amount to about Rs.500 per annum on the average.

The herbarium library is not large, but it contains most of the publications of old authors. Here again absence of funds is our handicap.

Volume I containing Parts I and II (Thalmifloræ and Discifloræ) of the Flora of Assam has already been published and Volume II (Calycifloræ) is in the press. Volumes III and IV are being prepared for the press.

Two numbers of the Forest records have been published by Mr. A. Das, (I.F.S. Retd.) containing the new plants of Assam and it is very likely that some more species new to Science will be discovered.

21. J. J. Asana, Ahmedabad.

The Gujarat College Herbarium, Bombay Presidency.

Origin and history: The Gujarat College Herbarium was started by Prof. W. T. Saxton, M.A., F.L.S., I.E.S., I.A.R.O., in the year 1914. He was in sole charge of this herbarium till 1922. This herbarium came into existence mainly due to his efforts. He was assisted in his work by the late Mr. L. J. Sedgwick, B.A., F.L.S., I.C.S.

The collections included in the herbarium: The herbarium includes all the plants of Northern Gujarat, which have been systematically recorded in his paper 'Plants of Northern Gujarat' by Saxton and Sedgwick published in the Records of the Botanical Survey of India, Vol. VI, No. 7, 1918. It also contains a fairly large collection of plants from other parts of India specially Kashmir, Murri Hills, Mount Abu, Castle Rock and other places. There are about 3,000 plant specimens in the herbarium. Lately Mr. R. N. Sutaria, B.A., M.Sc., who is on the staff of the Biology Department, Gujarat College has added several interesting specimens of plants of South Gujarat.

No special staff or special library is attached to the herbarium. There is no special exploration grant.

22. Sir Arthur Hill, Dr. K. P. Biswas, Dr. K. Bagchee, Dr. M. Mitra, Mr. Narayanswami, Dr. K. C. Mehta, Prof. Bharucha and others took part in the discussion. Prof. B. Sahni then summed up the position and requested Prof. Agharkar to make concrete proposals.

It was agreed that (1) there was a necessity for a National Herbarium in India, (2) that the Sibpur Herbarium should form the basis for this, (3) that it was necessary to strengthen the scientific staff of Sibpur, and (4) that the existing provision for 'Assistant for India at Kew' should be utilized for training personnel.

It was resolved to appoint a Committee of the following to prepare a workable scheme on the above basis and submit it to the proper authorities:

1. Prof. S. P. Agharkar, Convener.
2. Prof. B. Sahni.
3. Dr. K. P. Biswas.

4. Dr. K. Bagchee.
5. Mr. S. N. Bal.
6. Dr. K. C. Mehta.
7. Dr. M. Mitra.

Sir Arthur Hill was not included in the Committee as he was leaving India, but it was agreed that the Committee should work in consultation with him. It was further agreed that Brevet-Col. R. N. Chopra be also consulted whenever necessary.

The Committee has since met and forwarded its recommendations to the authorities concerned. A statement on the subject will be submitted to the 26th Session of the Indian Science Congress Association to be held at Lahore.

XXVIII. THE DISSEMINATION OF CEREAL RUSTS IN INDIA.

(*Section of Botany.*)

Prof. J. H. Mitter presided, and Prof. K. C. Mehta opened the discussion.

1. Prof. K. C. Mehta, Agra.

Opening Remarks.

In the year 1923, the writer started a study of the factors concerned, in the annual outbreaks of rusts on wheat and barley in the plains of India. The present state of our knowledge on the subject is summarized below:—

(i) There is no local source of infection in the plains at the time of new sowings (October–November).

(ii) Weather conditions are quite favourable from October onwards yet no rusts appear at most of the places for as long as 3–4 months from the time of sowing.

(iii) Evidently rusts are re-introduced into the plains year after year from somewhere.

(iv) In contrast with the death of all uredospores in the plains, due to heat, after the harvest there is conclusive evidence of oversummering of all the rusts under study, in the hills.

(v) Year after year, rusts break out earlier and plant for plant there is heavier infection at the foot of the hills than at places farther off.

(vi) Still earlier outbreaks (November–December) have been found on the hill crops that are sown during October–November. In the case of early hill crops (sown April–June) rusts have been found during June–September.

(vii) As far as the plains are concerned, *Berberis* and *Thalictrum*, which occur only in the hills, seem to paly little part in the annual origin of black rust of cereals and the brown rust of wheat respectively.

Both these rusts break out year after year at the foot of the Nepal range and in the plains of Peninsular India during December–January i.e., 3–4 months before their alternate hosts which occur only in the hills, could ever get infected.

(viii) At the foot of the Nilgiris these rusts have been found to appear as early as September–October in miniature plots sown at the request of the writer during June–August

(4 and 2 months respectively before the normal crops). It may be pointed out that every year these rusts are found in abundance by August at altitudes of 6-7000 ft. in the Nilgiris on the first crop (sown April–June).

Since the year 1930 a good deal of work has been done on rust dissemination but the period of study is too short for an explanation of outbreaks in the country as a whole, at any rate, on the basis of wind trajectories. Still two important foci have been located wherefrom rusts spread to the plains.

Rust spores have been caught from the air on stationary slides, exposed in aeroscopes at a large number of stations in the country, long before the appearance of the rust in question on the local crops.

Nearly 8,000 wind curves have been studied so far, out of which a considerable number have been found to be significant. The course of such winds in the case of some of the stations is of special interest and points to dissemination of the rusts concerned from hill stations, where on account of oversummering and earlier sowings (April–June in the South and July–August in the North) they had been found in abundance a few weeks before.

Annual rust epidemics over large tracts of the country should be effectively controlled by stopping this *early* dissemination of rusts to the plains by the following means:—

(i) In Nepal, wheat and barley should not be sown anywhere before October.

(ii) The first crop of wheat and barley (sown April–June) in the Nilgiris and Palni hills should be suspended.

Rigorous destruction of self-sown plants and tillers of wheat and barley, on which rusts oversummer, 1–2 months before the sowings in all hills and hilly tracts should help considerably in the control of rust outbreaks in general.

The speaker showed lantern slides, maps, charts and wind trajectories in order to illustrate his remarks.

2. Prof. A. H. R. Buller, Manitoba.

In western Canada there are no Barberry bushes and yet the wheat is attacked every year by *Puccinia graminis*. The source of infection consists of clouds of uredospores which are carried by northerly winds for hundreds of miles from the middle-western parts of the United States to Canada. In the southern part of the United States, *P. graminis* overwinters in the uredospore stage. A proposal has been made to breed rust-resisting wheats suitable for growth in the wheat areas of the southern States and thus to prevent uredospores being carried northwards to Minnesota and the Dakotas subsequently from these States to western Canada.

I have listened with great interest to the account given by Professor K. C. Mehta of his work on the Rust Fungi of India done during the past fifteen years. The practical measures which he now recommends should, if carried out, very considerably decrease the incidence of the Rust disease in India and so add to the food resources of this great country. Professor Mehta recommends: (1) that in Nepal, wheat and barley should be sown in October instead of August–September; (2) that in the Nilgiri and Palni hills, the first crop of wheat now sown April–June, should not be sown at all, but should be replaced by some other crop; and (3) that in the hills in general, self-sown plants and tillers of wheat and barley should be destroyed 1-2 months before the sowings. All these recommendations seem to me to be wise and practical and I trust that the Government will see its way to carry them out, particularly No. 2, which would mean the suppression of wheat crop which is grown on only about 2,000 acres.

3. Dr. L. A. Ramdas, Poona.

1. If the source of rust was along the slopes of the Himalayas and of other mountain systems elsewhere in India, it is possible that the katabatic winds which flow down-hill practically every night in clear weather would convey the infection into the plains. During day time the anabatic (up-valley) air currents would carry the spores upwards and the chances of such spores infecting the plains would be more remote.

2. The spores conveyed into the plains by the katabatic winds would during day time be dispersed into the upper air layers by the diurnal convective movements. The problem is to find out whether particles having the size of rust spores will have a sufficiently rapid rate of settling to become sources of infection on a sufficient scale.

3. One process by which such settling down of rust spores in the upper air may take place quickly would be by means of rain-drops which can form on them whenever there is the necessary supersaturation in the upper air. If that happens it would be easy to account for some of the misfits regarding dates of incidence which are found by Prof. Mehta.

4. In all phenomena where questions like 'Source' and 'Dissemination' are involved one important fact to establish is the most usual variation of the factor in question with elevation above ground. Unless this is done it may be difficult to assess the relative importance of the different air layers as 'significant'[1] layers in so far as their disseminating power is concerned. Ordinarily, one may be led to expect that the nearer a 'significant' air layer is to the ground, the more likely the significance may be taken to be.

5. In investigations where 'coincidences' of certain factors are sought for in order to fit in two observed sets of data, it is important to remember that 'non-coincidences' should also be sought for without bias in order to bring out the relative importance of 'fits' and 'misfits'.

6. The cereal rust research in India under Prof. Mehta is one of the problems in which meteorology plays an important part. Prof. Mehta is to be congratulated on the success with which he has been working out the problem.

4. Dr. H. Chaudhuri, Lahore.

I have had opportunities of following Prof. Mehta's work and also discussing with him the problem several times during the last 10 years or so. I have no doubt that the incidence of rusts in the plain has no connection or perhaps very little connection with aecidiospores on *Berberis* in the hills. Again there is no doubt that rusts in an epidemic form occur earlier near the foot of the hills e.g., Pathankot, Gurdaspur, etc., in the Punjab, than places further away in the plains. We know also that uredospores from the previous years' crop cannot survive the heat of the plains and that viable uredospores are found in the low hills practically throughout the year. Prof. Mehta has proved by very convincing data how the spores from the hills are carried by the wind and bring about infection. He has also suggested very practical means of controlling rust—at least to an appreciable extent—by shifting the time of the wheat-sowing over a small area in the Palni and Nilgiri hills and by growing early ripening varieties in Nepal which are foci from which infections are carried over considerable areas. It seems very important to me that Government should as a test measure carry out Prof. Mehta's suggestions for a couple of years in the Palni and Nilgiri hill centres. If successful,

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[1] Prof. Mehta calls certain wind trajectories at particular levels which show evidence of having started from rust-infected regions as 'significant' trajectories. Such trajectories are found by him to fit with the sequence of dates of incidence reported from observing stations along the trajectory.

the amount of saving will amount to several million rupees. The Government and the people realize the huge amount of loss sustained by the country and I think this body of scientists who no doubt feel convinced about Prof. Mehta's work, should press the Government to take it up at once and try to save the wheat lost through rust attack, for the country. Prof. Buller has mentioned in the course of discussion that in 1914 by facts and figures and propaganda, he convinced the Government of his country that a huge amount of the food of the soldiers on wheat was being eaten up by the rusts and that some could be saved by eradicating the *Berberis* plants. Professor Buller has told us of the astounding fact that in a week's time, he was able to free his country from *Berberis*. Prof. Buller is very fortunate in coming from a country where people not only realized the gravity of the situation but worked accordingly to the advice tendered by the scientists. It is, however, all so very different in our country. If Government in our country worked according to the advice of the scientists and spent even a fraction of the amount lost through diseases for remedial measures, the condition of the people would be different. Prof. Buller emphatically stated that the measures suggested by Prof. Mehta were very practical and should be adopted without delay. He also said that breeding a wheat which would resist all the three rusts which occur over the greater part of this country was a very difficult job and was likely to take a very long time.

I am therefore strongly of the opinion that the Government of this country should take early steps towards necessary legislation so that the methods of control proposed by Prof. Mehta be enforced. It is of the utmost importance that as much of this colossal sum of money that is being lost every year be saved as possible. In the case of results of applied importance, it should not do to stop with a scientific report and I am sure this meeting will lend its fullest support to the views that have been expressed by Professor Buller and others.

5. Prof. K. C. Mehta in reply to Ramdas's question regarding the importance from the statistical view-point of trajectories that have not been found to be significant, said that arrangements had been made for their examination by a statistician.

XXIX. ALGAL PROBLEMS PECULIAR TO THE TROPICS, WITH SPECIAL REFERENCE TO INDIA.

(Section of Botany.)

Prof. F. E. Fritsch presided, and Prof. M. O. P. Iyengar opened the discussion.

1. Prof. M. O. P. Iyengar, Madras.

Opening Remarks.

The study of algæ, as compared with the other branches of Botany, is quite a recent one in India. For quite a number of years only a few botanists were studying the subject. I am very glad to find that more of our botanists are now taking to its study.

We are extremely fortunate to have amongst us today Prof. F. E. Fritsch, the world's foremost authority on algae. You may be interested to know that Professor Fritsch is not new to our country. He came to

Ceylon about thirty years ago and made a special study of the algæ of the place and has given in two valuable papers an excellent account of the algal ecology of Ceylon and also of the tropics in general. From my experience of the algal flora of India, I find that his remarks regarding the algal ecology of Ceylon are equally true in most respects of the algal flora of India also. I am sure, you all, like myself, are eagerly looking forward to hearing his valuable remarks on our algal problems.

Lakes and Larger pieces of water.

While the general characteristics of temperate inland waters have been very thoroughly studied by a number of very eminent algologists, the characteristics of tropical waters have not yet received the attention they deserve. Only a few tropical lakes have been investigated so far in some detail especially in Africa and in Java. But as regards Indian waters we may say that practically no work has been done so far.

The waters of temperate regions may be classified broadly under three main types, (1) the Oligotrophic, (2) the Eutrophic and (3) the Dystrophic.

Oligotrophic lakes are characterized by very great purity of the water with an extremely low mineral content and a very great clarity of the water, with the result that light penetrates to a very great depth in these waters. The dissolved oxygen is distributed more or less uniformly from the top to the bottom and the *p*H value also is uniform likewise throughout. The silt is very poor in quantity and the organic matter is very low and the small quantity of CO_2 that is present is found just above the silt. The colour of the water is bluish. The algal flora is very small in quantity though the number of species is fairly large. The algæ are distributed more or less equally from the top right down to the bottom and are able to flourish even in the lowermost regions, owing to the easy penetration of the light to that region.

Eutrophic lakes are characterized by a very high dissolved mineral content especially of nitrates and phosphates. The colour of the water is greenish-yellow and light does not penetrate very much into the deeper layers. The algal flora is very rich though the number of species is comparatively small. The amount of silt is very large at the bottom and the dissolved organic matter very high. The dissolved oxygen is found more near the upper portion of the lakes and the carbon dioxide is very large in quantity above the silt; and bacterial activity is very high in the lower regions. The *p*H value is higher above and lower near the bottom. The algal flora is more concentrated near the upper layers and during the midday there is a very great amount of supersaturation of oxygen owing to the assimilatory activity of the algal plankton. The plankton organisms keep continuously dying and falling the bottom of the lakes with the result that a large amount of silt continuously accumulates. Owing to the decay of the organisms at the bottom, the oxygen at the bottom layers is used up and a large amount of CO_2 accumulates in the region. Owing to the lack of sufficient light in the bottom layers and also the necessary oxygen the algal flora is very poor in the lower strata.

Coming to the *Dystrophic lakes* the waters of these lakes are characterized by the presence of a large quantity of humic acid and a great poverty of mineral salts. Even though the mineral salts are introduced into these waters from any source, they immediately combine with the humic acid and get precipitated to the bottom as insoluble compounds so that even though the mineral salts are there in the lake, owing to their insolubility, they are not available for the plankton algal organisms. The bottom silt is sufficiently large in quantity and the colour of the water is brownish to dark brown. The number of plankton algal organisms is small, and so also the number of species. Owing to the acidity of the water the bacterial activity is low so that not much of putrefaction takes place and the mineral salts available from the dead organisms do not return to the water.

Besides these three different types of lakes (viz. Oligotrophic, Eutrophic, and Dystrophic), a number of intermediate types are also described by various authors, but for our purpose it will be enough to accept only these three types.

In India, especially in the tropical portion of it, we do not have any large lakes like those of the temperate regions, but we have various types of smaller waters. It would be very interesting to find out how far these smaller pieces of water conform to the different types found in the temperate regions. So far as I have been able to find out, most of our waters here appear to be more or less eutrophic in character but detailed investigation is needed to decide the exact nature of the several waters. From what I have seen of them, it looks as though an entirely different kind of classification would be required for our waters. There is plenty of scope for the algologist for research in this direction.

Exact data are lacking as regards stratification and circulation in tropical waters. In temperate lakes, during the summer months the surface layers show the highest temperature and the temperature decreases downwards, the lowest temperature being found at the bottom. This decrease in temperature downwards is, however, not uniform. The temperature decreases steadily and gradually downwards up to a short distance from the surface and then there is a sudden fall, and then the decrease in the temperature is steady once again and more or less uniform right down to the bottom. The region where there is a sudden fall in the temperature is known as the *thermocline*, the region above the thermocline is known as the *epilimnion*, and all the region below it is known as the *hypolimnion*. Towards the approach of autumn the surface temperature gradually goes down. And, as the temperature goes down, the water in the surface layers becomes, owing to its lower temperature, bulk for bulk heavier than the water in the lower layers and so keeps sinking continuously downwards with the result that a sort of a convection current starts. This process goes on continuously until finally all the layers reach a uniform temperature of 4°C. As a result of this convection current a complete rotation takes place bringing about a total mixing up of the water of all the different layers. This is called the autumnal circulation. But as the season advances and winter approaches, the temperature of the surface waters becomes still further cooled down, i.e. below 4°C. But, since water at 4°C has got the maximum density, the water of the surface layers, when cooled down below 4°C, expands and becomes bulk for bulk lighter than the water of the lower layers, and the convection current stops. In the height of winter, the surface layers show the lowest temperature (0°C) and the bottom layers the maximum temperature (4°C). Here also there is a thermal stratification, but the stratification is the reverse of what is seen in summer, and is called an *inverted stratification* as opposed to the summer stratification which is called a *direct stratification*. In spring, the temperature of the surface layers goes above 0°C, and the water in the upper layers becomes bulk for bulk heavier than the water of the lower layers and so falls downwards and causes a convection current which continues until the whole body of the water reaches a temperature of 4°C. As spring advances and the temperature of the surface layers goes above 4°C, the convection current stops and as the season advances the upper layers become gradually warmer and warmer than the lower and by the beginning of summer a definite stratification (direct stratification) is finally established. Thus there are two periods of circulation, one in autumn and another in spring and two quiescent periods —a very long one in summer and a very short one in winter. These latter periods are known as the *summer stagnation* and the *winter stagnation*, respectively. During these two latter periods, there is a definite thermal stratification in the lake, the stratification being direct in summer and indirect in winter.

We do not know how far a similar thermal stratification over a fairly long period is present in our waters. Since the bottom temperature

in our tropical lakes of India never reaches 4°C, it being mostly about 12 to 15°C even in the coldest part in the year, the type of circulation that is found in the temperate regions is therefore not at all possible in our lakes.

Ruttner, while working on some lakes of Java, Sumatra and Bali islands, comes to the conclusion that a definite stratification is found in some of the deeper lakes and that a sort of a thermocline also is noticeable. Worthington Beadle, Hutchinson and Riccardo, while working on some tropical African lakes, have on the other hand come to the conclusion that no thermal stratification nor any thermocline could be seen in the African lakes that they investigated. Further careful work is needed to establish the question of stratification in tropical waters. In this connection it may be mentioned that S. V. Ganapati and myself observed a kind of stratification in the Red Hills Lake which supplies water to the Madras town. This lake is a very shallow one, its greatest depth being about 25 feet. In the early morning, the temperature of the water is uniform from top to bottom. As the day advances, the upper layers become heated up and are slightly higher in temperature than the lower ones and by about 2 P.M. a definite thermal stratification is established. But towards the end of the day, the water in the surface layers begin to cool and, becoming heavier than that of the lower layers, begins to sink down continuously with the result that, owing to convection currents, a definite circulation starts and continues throughout the night bringing about a complete mixing up of the water. By about the early morning, owing to this circulation, the water becomes more or less uniform in temperature in all its layers. The next day the same process is repeated again. Thus every day the water shows a uniform temperature from top to bottom in the early mornings. By about midday, a definite thermal stratification is established. As the evening approaches, the stratification is gradually broken up and before the next morning a complete uniformity of temperature is established once again. So there is seen here a daily formation of a thermal stratification in the course of the day and a daily breaking down of this stratification during the night. This type of stratification may be called a 'temporary diurnal stratification'. There is thus a daily building of a thermal stratification and a daily breaking down of this stratification, associated with a daily circulation which brings about a complete mixing up of the waters from top to bottom. The water of the surface layers, which owing to the photo-synthetic activity of the algæ gets highly super-saturated with oxygen in the daytime, reaches the bottom every day and the CO_2 produced at the bottom through bacterial activity is distributed to all the parts of the lake and becomes available to the assimilating plant organisms.

Miss Mercia Janet and myself investigated the waters of a small artificial tank in a garden in Madras. The tank was hardly 2 feet deep and we found the same sort of making and breaking of a thermal stratification, associated with a complete rotation every day.

How far this type of stratification is seen in various other pieces of water in India will have to be further investigated. Wind of course helps a great deal in bringing about a mixing up of the waters in the tropics as pointed out by Whipple, Ruttner, Worthington and others. This was observed in the Red Hills Lake also. On windy days the temporary diurnal stratification was invariably absent.

The Algal Flora of temporary Waters and their Succession.

There are two kinds of temporary waters, (1) rain water pools which dry up after a very short time, and (2) small pools or ponds which dry up during the hot season. The rain water pools dry up generally within a short time after the stopping of the rains. These pools after a few days become very green owing to the very large quantity of algæ which come up within a very short time, causing a kind of water-bloom. The

algæ that are generally found in these waters are mostly members of the Volvocaceæ and with a sprinkling of a few members of the Protococcaceæ. If the waters of these rain pools become contaminated by sewage water a large number of Euglenineæ also come in. These rain waters are rather interesting. Owing to the frequent intermittent light showers, these pools become filled up with water for a few days and then get dried up during the succeeding rainless days and again become filled up with water and then again become dried up. In this manner these pools become filled up and dried up several times and every time they get filled up with water it is interesting to note that the same algæ come up again and again, though towards the end the green algæ yield place to the Euglenineæ and also to some blue-green algæ. It is rather interesting to note that blue-green algæ play a very subordinate part in these rain water pools.

As regards the deeper pools which retain the water for long periods and get dried up only during summer, they harbour a fairly rich algal-flora. If the water is not too much contaminated with organic matter they show a rich growth of green algæ including plenty of desmids. If, on the other hand, the water is rich in organic matter or is contaminated with sewage matter, blue-green algæ, Euglenineæ, and diatoms preponderate. These deeper pools show all kinds of variations from nearly pure waters, through varying grades of organic contaminations to very badly polluted waters. A corresponding difference is seen in the nature of their algal flora. It would be very interesting to investigate these tropical pools in full detail and gather data regarding the correlation that exists between the nature of the water and the nature of the algal flora.

The algal succession in these deeper pools is very characteristic. The pools get filled up to the brim and often overflow the banks during the rainy season. When the water level begins to go down, the first algal forms to appear in the water are mostly Volvocaceæ. After a short time, other members of the Chlorophyceæ gradually come in. If the water should be fairly soft, desmids also become fairly noticeable. One marked feature is that during these early stages blue-green algæ are absent. If the water should be polluted in any way with sewage matter, then a certain amount of Euglenineæ come in. As the season advances and the level of the water goes down a few blue-green elements come in and gradually increase in quantity as the temperature goes up and the water gets more and more concentrated. Towards the beginning of summer most of the pools become very nearly dry and by that time most of the chlorophyceæ disappear, the chief forms in the pools being blue-green algæ. Finally the pools dry up completely. This kind of succession, viz. green algæ first and then as the season advances blue-green algæ next, is seen not only in pools that dry up completely in summer but also in permanent pools which retain some water even during summer. The same kind of succession is seen also in the larger pieces of water such as irrigation tanks. Here also just before summer, the water is practically free from any green algæ, most of the algæ present being blue-greens and diatoms. This kind of succession has been very clearly described in detail by Fritsch in his very interesting account of the algal flora of Ceylon. Whether this kind of succession is due to the increased temperature or light intensity or to the increased concentration of the water or to other causes will have to be very carefully investigated. There is also just the possibility of the increasing organic matter of the water which accumulates through the continuous death of the plant organisms as the season advances, having some effect in determining this succession.

Another point in connection with these temporary pools which dry up completely in summer is that some of them harbour a rich desmid flora. Most of these desmids are able to form zygospores and are thus able to tide over the long dry period. This point is interesting, because there is a general belief among algologists that desmids cannot thrive in temporary waters, owing to the fact that they do not form usually zygo-

spores or resting spores of any kind quickly and so would be killed if the water should get dry. This is true of temperate climates where the desmids do not form zygospores quickly and where zygospores of several species are unknown. But in the case of the South Indian forms, my experience shows that a large number of desmids form zygospores very readily. In this connection it would be interesting to point out that Miss Rich found that some of the temporary pools of South Africa which dry up in summer harbour a large desmid population and that most of these desmids form zygospores very readily like our desmids and tide over the dry period and are thus well adapted to the conditions of the drying pools of that country.

Another very interesting phenomenon was observed by me recently. In a rain water pool in the Madras beach a species of *Cosmarium* came up suddenly in large numbers. The maximum depth of the water in the pool was only about a foot and the desmids formed a green layer about $\frac{1}{4}$ inch thick at the bottom. One could practically scoop up the mass of desmids in one's hands. This green mass contained millions of this desmid and appeared like a thick green soup. When the water in this pool began to go down, I watched the desmids daily until the water completely dried up. When all the water disappeared, the desmids were still lying on the moist soil as a thick green gelatinous layer. An examination of a little of this material showed a few zygospores, but the main mass consisted only of vegetative individuals. As the soil began to get drier and drier, the gelatinous mass also gradually dried up into a thin brownish layer and finally crumbled into pieces and formed part of the soil. The desmid was watched as the gelatinous mass dried up gradually. All the individuals with the exception of a few which formed the zygospores gradually got shrivelled up and finally dried up in their vegetative condition only. Some of the soil containing the dried up desmids was put into fresh water and kept in the laboratory. The shrivelled up desmids became green and regained their original shape, but did not thrive long in the laboratory cultures and died finally. The point to be noted is the temporary revival of these dried up individuals when placed again in water. It would be interesting to find out whether in nature they are able to tide over the long dry period in their dried up vegetative condition. The fact that some of the individuals could revive after being dried up for a time is rather interesting from the point of view of their dispersal. According to the current view desmids are unable to cross ocean barriers since they will die very quickly if they are dried up in their vegetative condition and also because they form zygospores only rarely. But if desmids could form zygospores quite readily like our forms, if they could withstand a temporary drying up in their vegetative condition to a certain extent, it is quite possible for them to get dispersed by wading birds by being transported in the mud sticking to their feet, over long distances and also across ocean barriers which some of these birds are able to cross.

Pieces of water with permanent water-blooms caused by species of Microcystis.

In South India a large number of tanks and pools, especially in towns, are green throughout the year. They may be said to have permanent water-blooms. The green colouration is due usually to a single alga, generally a species of *Microcystis*, though frequently the *Microcystis* may be associated with planktonic species of *Oscillaria* and *Arthrospira*. These waters are slightly alkaline and are rich in organic matters and contain a large amount of chlorides. These tanks are utilized by people throughout the year for bathing purposes and the water does not appear to have any harmful effect on the bathers. Many tanks connected with temples have got this permanent water bloom. The algæ of these tanks seem to suffer, however, when the rainy season comes in and the sky remains

cloudy for a long period. They then begin to die and float up in large quantities, emitting a nasty smell throughout the rainy season. Their death is evidently due to lack of sufficient sunlight, as it is continuously cloudy for a fairly long time during this season. The water of these tanks during the greater portion of the year, owing to the assimilation of the algæ, is highly super-saturated with oxygen from top to bottom. It would be interesting to investigate these pools in detail especially in view of the fact that some of the blue-green algæ have been reported by several authors to be very harmful to animals drinking the water.

Paddy-Field Algæ.

The rice plant in our country is cultivated in the same fields for generations. In spite of this the yield of paddy continues, undiminished from year to year.

Every year a large quantity of nitrogen is removed from the soil in the shape of crops. A certain amount of nitrogen is put back into the soil in the shape of the crude manure that is applied by our agriculturists, but this is very small and is not sufficient to replace the large amount of nitrogen taken out of the soil. It is also known that the nitrogen content of Indian soils is very poor in quantity, though phosphates, potash, etc. are found in sufficient quantities to supply them over long periods. How in spite of all this every year the yield of paddy happens to be the same was not quite clear. During recent years, our biochemists (P. K. De, Sen, Viswanath and others) have been tackling this problem and have come to certain very interesting conclusions. Plenty of algæ are found in the waters of paddy fields and these algæ are found associated with nitrogen-fixing bacteria. These investigators think that the bacteria obtain some carbo-hydrates from the algæ and are then able to fix up the atmospheric nitrogen. This according to them accounts for the continuous addition of nitrogen to the paddy fields year after year.

Another group of workers (Dhar, Tandon and others) think that the paddy-field-soil itself is capable of fixing the atmospheric nitrogen without the help of any bacterial activity. The soil is able to do this through photochemical reactions in the presence of the carbo-hydrates supplied by the algæ. This view, however, is not very much accepted by the majority of the biochemists. In this connection it would be interesting to point out that Allison and Morris claim that the blue-green algæ themselves can fix up the atmospheric nitrogen without the help of any bacteria. How far this claim is justified will have to be decided by further investigation. Pure cultures of these blue-green algæ have been grown by some workers and it has been pointed out by them that the blue-green algæ in the absence of the associated bacterium is unable to fix up the atmospheric nitrogen.

Plenty of further research is therefore needed to decide how far the algæ are really helpful in maintaining the nitrogen supply of the paddy fields.

Algæ of Estuarine Regions.

The algal-flora of the estuarine regions is very interesting. The water during the flood season is mainly pure water, but during the rest of the year, when the flow in the river has stopped more or less, the water becomes gradually more and more brackish. Sometimes, near the mouth of the river, the water is nearly as concentrated as the sea-water itself. The algal flora, when studied throughout the year will show several interesting features. The algal flora of estuarine regions are studied in detail in western countries. G. Venkatraman and myself are now studying the diatom flora of the Cooum estuary at Madras during the several seasons. During the monsoon period when the water is practically pure the estuarine region contains only the pure water species. On the other hand, when the water is very brackish, quite a number of marine forms

come in and all the fresh water forms which were present previously die out. Some forms, however, are present more or less throughout the year under varying conditions of salinity. These forms are presumably those which can accommodate themselves to the increasing or decreasing salinity of the water.

We have plenty of estuarine regions in India. A study of the algal flora during the different parts of the year and the range of the different forms within the estuarine region and also higher up the river will throw much light on the capacity of the several organisms to adopt themselves to the varying conditions of salinity. It would be interesting to have exact data regarding the algal flora of our estuarine regions.

Algæ in relation to aquatic animals.

These can be classified under two important divisions: viz. (1) Algæ which are epizoic and are living on aquatic animals, and (2) Algæ as which form the food of animals. Quite a number of algæ living on the surface of the aquatic animals, for instance, some species of *Cladophora* are found growing on the shells of water snails, and some species of *Characium* on some crustaceans and some on Anophelene larvæ. These algæ by growing on moving animals are able to tap a larger supply of dissolved gases and salts through the movements of their animal host in the water. It would be interesting to note all such algal organisms that lead an epizoic life.

Coming to algæ as food of animals, it may be mentioned that algæ form the food of minute animalcules in the water and these tiny animals in their turn form the food of larger animals and these again of still larger animals and so on, until finally of the larger animals like fishes. Thus the fishes in the water really depend in a way though indirectly upon the algal population in the water for their food supply. It would be interesting to find out the nature of these 'food chains' i.e. from the algæ to the largest animals in the several pieces of water in our country. In pisiculture, this question is coming up largely to the front and investigations of such food chains in our waters will help materially in the development of pisiculture in the country.

Algæ and Mosquito larvæ.

Algæ are largely used as food by the larvæ of mosquitoes. Several workers have tackled this question. Rudolfs, Barbar, Buxton and Hawkins, Senior White, Lamborn, Hamlyn and Harris, Boyd and Foot, Howland, M. O. T. Iyengar and others. Two views are at present current regarding this question. One view is that the mosquito larvæ are specific in their food relations, i.e. that a particular species of mosquito larva depends for its food on a particular algal species and that in the absence of the alga or algæ in question the larva is unable to live. If this should prove to be the case, then it would be possible to control any particular mosquito by controlling the growth of the corresponding alga. The people holding the other view maintain that the mosquito will eat anything which comes in its way and that it is not specific in its food relations, and that, in the absence of the algæ, it will eat any other available food. And even, if a mosquito should depend on algæ it is not partial to any particular species or genus. Any alga is welcome and will form its food. So the two views summed up come to this: (1) that a positive correlation exists between the distribution of the mosquito larvæ and the distribution of the algæ forming their food, and (2) that there is no correlation between the distribution of the larvæ and the distribution of the algæ; if the algæ are present these are eaten by the larvæ. At present there appears to be more support for the second view. In India, the observations of Senior White on the feeding habits of the mosquito larvæ are more in favour of the latter view. In one case, however, a definite positive correlation has

been shown to exist between *Closterium* and *Anopheles punctipennis*, by Boyd and Foot. And a negative correlation was observed by them between Anophelene larvæ and Unicellular Cyanophyceæ. Another case of definite positive correlation has been recorded by M. O. T. Iyengar in Travancore. The larvæ of a species of *Mansonioides* live in pools in which *Pistia stratiotes* is growing in plenty. The larvæ, unlike other mosquito larvæ, do not come up to the surface to breathe, but dig their caudal portions into the roots of *Pistia* inside the water and get the necessary air from the intercellular air spaces found in the root of the *Pistia* and continue to live in that fixed condition. These pools, owing to the large amount of organic matter in them, support a rich diatom flora, and the mosquito larvæ live on these diatoms. An examination of the stomach contents of the larvæ shows a large number of diatoms in them. If the water in these pools is very pure and consequently poor in diatoms, then the larvæ are absent in the water.

2. PROF. F. E. FRITSCH, London.

Algal problems peculiar to the tropics.

I have listened with great interest to the very able opening remarks of Prof. Iyengar and have been especially pleased to find that he has put the ecological point of view in the forefront of his considerations. There is no doubt that the study of the ecology of freshwater algæ is of considerable economic importance, and because this has been recognized in England we founded some ten years ago the Freshwater Biological Association for the study of the biology of freshwater plants and animals. This association has a laboratory on Lake Windermere in the north of England where many diverse problems of freshwater biology are being investigated. We have called our Association the Freshwater Biological Association of the British Empire, because we felt that many of our problems will find a parallel in other parts of the Empire and we should welcome the co-operation of Indian algologists in solving some of our problems. I have come here to learn from my Indian colleagues and do not want to say very much.

It is difficult to discuss all the numerous topics raised by Prof. Iyengar. A study of the algal flora of rice-fields seems to me most important. Here you have a unique artificial, but very ancient, type of habitat which has no direct parallel in temperate regions. What we want to know is how far there is a uniform type of algal flora (not necessarily extending to detailed specific constitution) in the rice-fields and how far it shows a uniform periodicity. To solve that, team-work on the part of investigators all over India is necessary. Such knowledge will help markedly towards the solution of the problem of nitrogen-fixation in rice-fields, which are still very unclear.

Prof. Iyengar referred to the characteristic features of tropical lakes and to the work of the German Sunda-expedition. This work has disclosed marked differences in thermal relations, oxygen-distribution, etc., in tropical and temperate waters and more particularly in those of the oilgotrophic type. In India, with its wide range of climatic conditions, these different types could be studied in detail and their exact relation to one another established. The small pools do not seem to me to be of the same degree of interest from the ecological point of view. As regards rivers I should like to see other parts than the estuaries investigated, as we know very little of the algal growth, apart from plantation, in tropical rivers.

Reference has been made to the abundant occurrence of water-flowers, usually due to *Microcystis aeruginosa*, in many of the small and shallow waters of South India. Organisms of this and similar types often cause analogous water-flowers in European waters, but this occurrence is not so regular and wide-spread. For many of them no means of per-

sistence from one period of occurrence to the next is known and yet during the period of 'absence' the persisting stages may perhaps be most vulnerable and most easily eliminated. Indian algologists can most readily study this question. At this point I may refer to the fact that for the majority of the Blue-green Algæ very little is known of the life-cycle, in particular of the numerous forms that occur in subærial habitats in the tropics.

Prof. Iyengar also referred to the problem of the relation between mosquito-larvæ and the algæ of the waters in which they occur. I have seen collections of algæ from mosquito-infected waters from diverse parts of the earth; the algal flora is very varied and I know of no definitely established relation except that recorded by Dr. M. O. T. Iyengar.

3. Dr. H. Chaudhuri, Lahore.

It is doubtful if the algæ themselves fix any nitrogen. The author has examined algæ, water and soil from the water-logged rice-fields of Bengal. He isolated the algæ from the water-samples and also the soil. The algæ were mostly blue-green and some green. Algæ with mucous coat had always bacteria in the sheaths. The different bacteria were isolated, and grown in culture for determining the power of nitrogen fixation. Some fixed nitrogen vary quickly, others slowly. These bacteria were also isolated from the soil. The very rapid nitrogen fixation in rice-fields with algæ is due to these bacteria. In the ordinary soil, the fixation by these organisms is very slow, because they cannot multiply so quickly as when in the field the algæ are multiplying and disintegrating. These disintegrating algæ act as culture media when the nitrogen fixing organisms multiply very quickly.

Growth of algæ is determined to a very large extent by the salts present in the medium and in the fields, they act as indicators. In the Punjab, in many canal-irrigated areas, the water-table has been coming up and we find salts being deposited on the surface. When these salts are deposited, the normal algæ of the soil disappear altogether. Due to further siltage from the canals, these areas gradually become submerged in water for a few inches to a couple of feet or more. In this condition, I have noticed miles and miles of submerged lands, in which only *Hydrodictyon* and a few other algæ could grow. I have also followed the reclamation of these water-logged lands in the Punjab by treatment with gypsum, and gradually the return of the normal type of algæ. Algæ as indicators offer a fertile and useful field of research.

4. Prof. S. L. Ghose, Lahore.

(i) In the Salt Lake at Sambhar, Rajputana algæ form a pest and affect the quality of salt produced, and there is a tremendous loss of revenue to the Government. The algæ of the Lake should be studied and measures for their eradication should be investigated.

(ii) The morphological and physiological nature of the heterocysts of the *Myxophyceæ*. It has been observed that the contents of the heterocysts in the tropics are more abundant and more marked in tropical than in temperate countries.

(iii) Algæ can be used as indicators of the quality of soil, such as alkaline land that is being reclaimed by chemical means.

(iv) The question of river pollution by algæ is not so important in India as in England, as most of the rivers are larger and swifter. Moreover, the population round them is not so thick.

5. Prof. S. P. Agharkar, Calcutta.

I wish to have some information about the method by which the penetration of light into thewaters of Indian lakes was measured. I further

wish to draw attention to the necessity of a study of the algæ of salt lakes of India. As regards the stage in which many of the algæ tide over the unfavourable season and why they are found at particular seasons only, there is very little information. This is the case with other organisms, including some animals, and it is desirable to investigate this.

6. Dr. B. P. Pal, New Delhi.

Dr. B. P. Pal gave a brief account of some experiments he had carried out in Burma to investigate whether charophytes exercised a larvicidal influence upon mosquito larvæ. In these experiments plants of species of *Chara* and *Nitella* were grown in jars and known numbers of mosquito larvæ were introduced into some of the jars. The larvæ flourished in these jars just as well as in the control jars (i.e. jars in which no charophytes were growing). The results indicated that the species of charophytes experimented with had no larvicidal effect upon mosquito larvæ. In the course of the experiments it was discovered that the charophytes sometimes harboured the larvæ of a species belonging to the *odonata*, which preyed upon mosquito larvæ.

7. Prof. Y. Bharadwaja, Benares.

Almost all the previous speakers have laid stress on the so-called economic aspect of the study of algæ on which practically no work has yet been done in India, and none has pointed out our difficulties in the morphological and taxonomic studies of these plants. While I strongly support that work on hydrobiology, limnology, pisciculture, etc. should be undertaken more or less on the same lines as followed in some of the foreign countries, I urge that the morphological study of these plants should not be neglected. We have not yet done much work on algology in India, and we must first know what kind of algæ grow in this country. The need for working out the algal flora of India is therefore imperative. This is a work of fundamental importance.

In order to know the species growing in this country we have at present to consult books on floras written by foreign authors. The descriptions of most of the tropical algæ given in these books are based on the study of preserved materials and they cannot therefore be considered entirely reliable. Algæ grow most abundantly in the tropical countries, and a sub-continent like India, with its varied climatic conditions and habitats, is the most suitable place for the study of these plants. My personal experience shows that in many cases species, even genera merge into one another through intermediate forms, and it is very likely that these are merely habitat-forms rather than separate plants. Such cases have been met with more abundantly in the *Myxophyceæ*, to the study of which I have devoted special attention, although they are not uncommon in the chlorophyceæ, such as the Ulotrichales, the Chætophorales and the Siphonales. I therefore strongly advocate a consistent study of the tropical algæ in the living condition from an ecological point of view to enable us to know their behaviour under different climatic and edaphic circumstances. I am sure such a study will bring out several interesting data which will nullify several genera and species that are at present recorded in books on algal floras written by those authors who had no opportunities of studying the algæ of the tropics *in situ*. In this respect the Indian algologists are in a position to contribute materially to the knowledge of these plants.

8. Mr. R. Senior White, Calcutta.

Though medicine has long recognized that it is essential to enlist the assistance of the entomologist in the solution of the problem of the

control of several insect-borne diseases, medicine has so far enlisted the assistance of the botanist only in the case of the disease trypanosomiasis. But with the entomologist, it is becoming very necessary that medicine should call on the algologist for help in the control of one, rather the principal, insect-borne disease of this country—malaria.

Malaria in the tropics will never be widely and generally controlled by the application of chemicals, for reasons of cost, and relief to the thousands of malaria-stricken villages in this and other tropical countries can only be looked for by the discovery and application of naturalistic methods of control, such as, from time to time, one sees nature herself apply to check the breeding of some malaria-carrying Anophelene. We are just beginning to make use of one or two of these naturalistic methods. The success of Ramsay's shade-methods in Assam, and of Williamson's herbage-packing method in my hand are cases in point. But we are quite ignorant of how such work. What change is caused in the water by densely shading it? Do we alter the flora on which the Anophelene feeds? Herbage-packing appears to act by de-oxygenating water, replacing algæ by fungi, but we lack any detailed chemical or botanical studies on the waters.

Taking seriatim the types of habitat discussed by Prof. Iyengar:

Rain pools.—I must disagree with Prof. Fritsch regarding their being of academic interest only. As a cause of malaria they are very important, in the North Centre of the country particularly. At times they produce the dangerous *culicifacies*, at others the harmless *subpictus* only, the reason appearing to be the amount of oxygenation, according to steady or to breaks in the rains. This lack of oxygen is not a direct effect on the larva, an air-breather. It is probably through the algal flora, an unstudied subject. I have published the algal study of an artificial rain pool, but that was only the start of such an investigation.

Rice Fields.—As Watson has said, food is even more essential than health, and therefore though rice-growing causes an enormous amount of malaria, it must continue. But all rice-fields are not malarigenous. Going from Calcutta to Madras they are so up to about the Orissa frontier, but not southward. Casual observation would suggest that this has something to do with the presence or absence of floating algal clumps (Chlorophyceæ), which are especially suited to *An. annularis*, the principal vector of the region. This algal growth seems less common in N. Madras. I would add my plea for the adoption of Prof. Fritsch's suggestion of detailed team-study of the algal flora of rice-fields.

Estuarine areas.—Here again I must join issue with Dr. Fritsch. The problems they present are not purely academic. They are highly important owing to the fact that they are the breeding ground of a special Anophelene, *sundaicus*, that has caused enormous suffering in deltaic Bengal, and is now a new-comer, causing havoc on the Chilka Lake. The problem of this Anophelene is very closely bound up with algal factors. It is probably a diatom feeder—diatoms turn the stems of the *Potamogeton* thickets brown—but it is to the plaques of dead *Potamogeton* bound together by *Lyngbya* that the mosquito owes its prevalance and security from its enemies, fish, etc., living in the narrow crack-like water-space between the plaques. If the algologist will tell me how to control the *Lyngbya*, I will control the epidemic.

I once belonged to the school that thought mosquito larvæ selective in their feeding, but I do not now do so, though there well may be some algæ more nutritious than others, thus accounting for larval prevalence. But freshwater algæ have yet to be analyzed for food values, as have some marine ones. But there is one mosquito, *Culex biteaniorhynchus*, that is entirely specialized, as its ventral plate shows, for feeding on one genus of algæ, *Spirogyra*. Williamson has recently shown that this mosquito, unique among the Culicines, is a vector of human malaria. Probably only academically so, but if there be found anywhere a place where this

mosquito is of any importance in malaria causation, then control of this malaria will be a matter of control of *Spirogyra.*

9. Mr. M. O. T. Iyengar, Calcutta.

Prof. Iyengar referred to the daily turn over of water in tropical ponds. I happened to make some observations, while studying the dissolved oxygen content of pond water, which appear to support his views. I observed that there is a diurnal variation in the oxygen content of surface water in ponds, which was highest at about 3 o'clock in the afternoon, and reached its lowest level in the morning at about 5 A.M. The rise in the dissolved oxygen content was associated with the solar radiation and the photosynthetic activity of the algal plankton. In the afternoon when the surface water (1″ to 6″ below the surface) showed a high dissolved oxygen content, the water at the bottom of the pond showed a low oxygen content. The surface water being warmer at the time, remained at the surface. The lowering of the atmospheric temperature after nightfall and the cooling of the surface water caused a circulation which resulted in the equalizing of the dissolved oxygen contents of surface water and deep water. From midnight till morning there was no difference in the dissolved oxygen contents of the surface water and deep water.

Prof. Iyengar referred to the work of Cabellero and others on the inhibitory action of *Chara* on mosquito breeding. I must say that the observations of Cabellero have not been confirmed by several of the later workers, and at present there is no evidence to show that *Chara* has any inhibitory action on mosquito breeding. Species of *Chara* with which I worked do not seem to have any harmful effect on mosquito breeding either in the laboratory or under natural conditions. I have in some cases seen numerous *Anopheles* larvæ thriving on the top of sub-aquatic brushes of *Chara*.

There are, however, a few algæ which appear to have some inhibitory influence. The presence of *Microcystis aeruginosa* in water appears to inhibit the development of most species of *Anopheles* with the exception of *A. subpictus* and *A. vagus.* I have also observed that ponds with a dense surface growth of *Euglena* are generally free from *Anopheles* larvæ.

There is another aspect of the influence of algal flora on mosquito breeding on which I have a few observations to make. Several species of mosquitoes of the genus *Anopheles* have specialized breeding habitats, some breeding in running water, some in seepages, some in brackish water, and others in fresh stagnant water. In many of these cases the selective habitat would appear to depend to a large extent on the availability of certain types of algal flora.

I give below two typical examples of the relation of algal flora to mosquito fauna.

In the foot-hill zone in Bengal the running streams are the important breeding places of *Anopheles.* Where these streams are covered with dense forest, the species of *Anopheles* found to breed are mainly *A. aitkeni* and *A. barbirostris,* species which are not concerned with the transmission of malarial infection. When such a stream is exposed to light, as for example, when the forest is cut down, the character of the *Anopheles* fauna is entirely changed. *Anopheles aitkeni* disappears completely and such species like *A. minimus, A. maculatus* and others known to transmit malarial infection breed in large numbers. The exposure of the stream to light causes a change in the algal flora, which inhibits the breeding of the harmless forest species and favours a heavy incidence of the malaria transmitting species. This change can be demonstrated by following a stream emerging from a dense forest into the open area. The differences between the shaded stream and the exposed stream as regards the algal flora and the anopheline fauna are indeed very striking.

This phenomenon has been utilized in malaria control work by preserving forests in the vicinity of streams and, where this is not feasible, by growing *Duranta* brushes on the sides of small streams to produce an artificial shade.

The second example relates to a mosquito known as *Mansonioides*, an important carrier of filarial infection in India. Unlike most mosquito larvæ which come up to the surface of water for breathing, the larvæ of *Mansonioides* has the interesting habit of inserting its breathing apparatus into the root of *Pistia stratiotes* and obtaining its supply of oxygen from the large air cavities in the cortical region of the root. Ponds covered with *Pistia* are generally poor in green algal plankton, and such green algæ as may occur are not available to the *Mansonioides* larvæ which leads a sedentary life attached to the roots shaded by the leaves of *Pistia* and an inch or two below the water surface. The food of the *Mansonioides* larvæ consists almost entirely of diatoms.

The occurrence of a rich diatom flora in ponds is closely related to the presence of some organic contamination, a common source being the decaying coconut husk steeped in ponds for the manufacture of coir. If such organic contamination is absent, the diatom flora is poor and *Mansonioides* fails to breed, although the other necessary factor, namely *Pistia*, is present. There is here a close relation between the presence of diatoms and the breeding of *Mansonioides*. The breeding of *Mansonioides* can be controlled by reducing the incidence of diatoms through eliminating the source of organic contamination.

Certain methods of mosquito control through altering the character of the water, as for example the herbage packing method, appear to be effective through the changes brought about in the algal flora of the water.

As a worker interested in problems connected with the ecology of mosquitoes, I cannot stress too strongly on the importance of studies on algal flora in relation to mosquito breeding.

10. Dr. F. R. Bharucha, Bombay.

The present discussion has brought out very clearly the importance of the inter-relationships of different branches of science for in the present discussion it is not only pure algologists who have taken part but doctors, entomologists, chemists, public health officers and ecologists. This interpendence of the subject is not realized in our medical research institutes like the Malarial Survey of India and Haffkine Institute, Bombay with the result that there are no posts of botanists in these institutes. Within the last one year several inquiries have come to me from such medical institutes for the identification of algæ and diatoms contaminating various types of waters. Industrial concerns and public health officers send their samples of contaminated water to such medical institutes and invariably due to an absence of a botanist on the staff, these inquiries do not elucidate any point. If a botanist is on the staff, he would do very useful work by analyzing the water samples from the point of view of an algologist and suggest means and measures to get rid of algal contamination or study these waters and make detailed ecological investigations with a view to find really profitable solutions for the prevention of infection by algæ and diatoms. Thus and thus alone, can the public health departments become really useful to the public. This point of the appointment of a botanist to the staff of a medical institute was also emphasized by Dr. Senior White, Malariologist to the Bengal Nagpur Railway who took part in the discussion.

11. Dr. Gilbert Fowler, Madras.

Dr. Gilbert Fowler (Madras) remarked on the importance of the study of Indian lakes as sources of water supply. In the past attention

had been confined to bacteriological pollution of water and the effect of storage on the viability of pathogenic organisms. Dr. Fowler had long urged the importance of limnological investigations, especially in relation to the water supplies of Bombay and Madras. The work of Prof. Iyengar and his colleague interested him greatly. From the economic point of view it was disappointing to hear that the problem of control of algal growth could not yet be considered to have reached a practical solution. The effect of the products of algal growth on the metal corrosive properties of the water was not properly understood. He would ask the investigators to study particularly the effect on algal growth of flow through closed conduits. In regard to effect of rate of flow of water on algal growth he would like to know what the critical rate of flow should be if danger of malaria was to be avoided. He must differ from the Chairman in his belief that the condition of Indian and European rivers was similar. It might shortly be said that in Europe there were large populations on small rivers, in India there were small populations on large rivers.

12. Dr. K. P. Biswas, Sibpur.

We are discussing a very vast subject on which very few of us have any comprehensive idea. I mean the discussion on 'Algal problems of the tropical countries of the globe'. Prof. Fritsch is the only authority here who can give us some idea from his early works on Ceylon and African algæ. But to tackle the various problems means continued study of algæ in different seasons in the field and in the laboratory, although, I admit there is some general similarity in the algal flora of the tropics as a whole.

It is better that we confine ourselves to the problems peculiar to India alone. Even then the study of the algal problems of such a large country as India with her diversity of climate is fairly a vast one. Again there are various aspects of the study of algæ. We have not yet taken even a census of the inland species belonging to the different classes of algæ occurring in all the provinces of India nor of all the sea weeds growing on the Indian coast. Some good work has been done in our country, but it is still very far from being complete. The systematic study of algæ which forms the background of all subsequent investigations is thus even now left far behind.

The study of algal ecology, both auto-ecology as well as syn-ecology, has also not been much attempted here. This is one of the most important subjects of study and has some bearing on economic aspects too. For example, we have—especially in Bengal and Madras—extensive rice-swamps. A systematic study of the algal ecology of these rice-swamps is of considerable importance to the growth of the rice crop. The amount of nitrogen fixation by these algæ is now being investigated by Mr. Dey in Prof. Fritsch's laboratory in London. The results of his studies will throw much light on this complicated question. Prof. Fritsch would further enlighten you on this subject. But, before taking up any detailed investigation in this direction, we must first of all know which different species of algæ grow in the rice-fields, in which area of the country, in what proportions and under what edaphic and climatic conditions. The capacity of each of these species to fix nitrogen will then disclose the usefulness or otherwise of the algæ growing in a particular rice-field. It has been found by Mr. Gardner of the Biology Department of Metropolitan Board, London, that the presence of certain members of the phytoplankton indicate an excess of certain mineral salts in the water in which they grow. Such discoveries are likely to improve the cultivation of rice in this country.

The importance of algal study in connection with the filter-beds of freshwater reservoirs has been emphasized by me in some of my publications both scientific and popular.

The importance of the study of freshwater algæ of tanks, jhils and lakes, particularly in a fish-eating country like Bengal, cannot be over estimated. Of equal importance is the study of the algæ of brackish waters like that of the Chilka lake, the Calcutta Salt Lakes, the numerous creeks of Sundarbuns and the extensive open water areas of Bombay along the sea-face which are the depository of many kinds of delicious fishes.

These are only a few of the problems and I have selected these as they have an applied side. The present question, as you are all aware of, is what is the use of this algal study ?

We have plenty of material for pure study. For example, the whole of the Himalayan area is almost untouched. The recent collections of algæ made by me and others in the area show that there is no dearth of algæ even at a height of nearly 20,000 ft. The study of the occurrence of algæ at the different altitudes would be very interesting indeed. Then there are numerous hot springs even at a height of 17,000 ft. in Sikkim and in Garwahl Himalayas. It is worth studying the algal species growing around the hot springs in the hills and in the plains. We find also numerous ephemeral, annual, biennial and perennial species of algæ confined to the deeper depressions of the half dried river-beds in various parts of Northern India. They harbour quite a large stock of interesting algæ.

The study of the distribution of all the different types of even some of the common associations of algæ is also very fascinating.

The physiologists and cytologists have yet to find out as result of their study, many important facts in the life-history of the various groups of Indian algæ.

To tackle all these problems requires men and money. We are certainly in want of the money if not in men. But, as regards Bengal and Madras, the study of the algæ of the rice-fields and the study of freshwater algæ of tanks and filter-beds are imperative. The Imperial Council of Agricultural Research, liberal as they are in encouraging every genuine attempt towards improving the crops, may be approached to provide funds for such a useful study. At least two or three research scholars can easily be provided. These scholars will work under the direction of an expert algologist. We shall therefore by such means have in the near future a band of trained algologists who, prompted by the interest of their study, will, I am sure, make algology a life-long study and would thus advance our knowledge of Indian algæ.

13. Prof. F. E. Fritsch, London.

Concluding Remarks.

As I said at the outset I have come here as a learner and I have indeed learnt much in this morning's interesting discussion. I have been particularly interested in the many contributions relating to the possible relation of algal growth and the occurrence of mosquito-larvæ and it is quite evident here that co-operation between the botanist and zoologist is desirable. The control of algal growth, whether in such waters or in water reservoirs, for instance, is however a matter requiring much further investigation. Very slight changes in the amounts of mineral salts or in the hydrogen-ion-concentration of the water may produce very marked changes in the algal growth present, and we are at present only at the threshold of understanding such changes. It seems probable that the control of algal growth will have to be attacked on a biological basis and that undue growth of algæ will best be checked by association with an appropriate fauna.

Some of my remarks were perhaps a little misinterpreted. I did not wish to suggest that the morphological study of the algæ be neglected, but that mere description of new species, until such species were known

to be of ecological value, was scarcely the best way of utilizing the abundant energy of the numerous workers on Indian freshwater algæ. How great a contribution Indian algologists can make to our knowledge of algal morphology is abundantly illustrated by Iyengar's work on *Tetrasporidium*, *Ecballocystis*, *Characiosiphon*, etc. and Bharadwaja's contribution on the morphology of the blue-green algæ.

XXX. DISCREPANCIES BETWEEN THE CHRONOLOGICAL TESTIMONY OF FOSSIL PLANTS AND ANIMALS.

(*Sections of Geology and Botany.*)

Dr. A. L. du Toit presided, and Professor B. Sahni, president of the Botany Section, opened the discussion.

1. Prof. B. Sahni, Lucknow.

Discrepancies between the chronological testimony of fossil plants and animals.

The question of a possible conflict between the evidence of plant and animal remains in fixing the ages of strata is not a new one, nor is it confined to the field of Indian geology. Like other many-sided problems it suffers from the inherent difficulty that the specialist has rarely, if ever, a full appreciation of evidence lying outside his own field.

Perhaps we shall never know how far our disagreements may be due to this factor. But the present occasion seemed to offer a unique opportunity for discussing our problem on broad lines, because we had looked forward to see here an international gathering of specialists representing different aspects of the question. For various reasons this hope has been only partially realized, hence our special thanks are due to those colleagues abroad who have sent us their views in writing although we could not have the benefit of their presence here to-day.

The sea has probably always covered the greater part of the earth's surface, as it does to-day. Accordingly most of our fossiliferous strata are marine, inspite of the great terrestrial formations of Gondwanaland in the south. As it was in the northern countries that the geological scale was first studied, our standard scale is primarily based upon marine animals, with the plant-bearing strata merely interpolated.

I have often wondered how a palæobotanist would classify the strata if he could possibly work on a clean slate, unfettered by previous ideas. In the Gondwanas, at least, he might quite probably place some of his major boundaries at horizons different from those in the European scale. But would this indicate a real discord in the age values of plant and animal remains, or would it be merely due to the well-known fact that in different parts of the world some of the major breaks in the rock-record occur at different periods?

The problem of these discrepancies, real or apparent, first confronted me about twelve years ago during a survey of the southern fossil floras, and I made a passing reference to it in an address to the geology section (*Proc.* 13*th Ind. Sci. Cong.*, 1926, pp. 246-247). Let us examine a few actual cases where the evidence from the two sources appears to be contradictory.

(*a*) *The Hawkesbury Series* (*N.S.W.*).—In Süssmilch's Geology of New South Wales (3*rd ed.*, 1922, p. 166) one reads of an astonishing

contradiction in the fossil evidence. The Hawkesbury series is generally included by the Australian geologists within the Trias.[1] The topmost member, known as the Wianamatta stage, contains a flora of Triassic (or Rhaetic) aspect, but of the eleven genera of fish recorded from St. Peters only four are said to be Mesozoic types, the rest being confined in Europe to the Palæozoic, in rocks ranging from Lower Carboniferous to Permian. In the accompanying table are indicated in parallel columns the broad affinities of the floras and faunas of the Hawkesbury series and related formations. It will be noticed that in the Hawkesbury stage (which is older than the Wianamatta) and in the Talbragar beds (which are younger) the fish are exclusively of Mesozoic types. *If the data are sound* we have here a predominantly Palæozoic fish fauna placed in the middle of a Mesozoic sequence, and associated with a Triassic or Rhætic flora. Whether the reported Palæozoic fish in the Wianamatta stage are really hold-overs or whether there is a flaw in the evidence is a question worthy of investigation.

	Strata	Flora	Fish Fauna
	Talbragar Series.	*Jurassic.*	(*At Talbragar*) *Jurassic*
Hawkesbury Series	Wianamatta stage	Trias or Rhætic.	(At St. Peters) 7 genera Palæozoic, 4 Mesozoic.
Hawkesbury Series	Hawkesbury stage.	Trias or Rhætic.	(At Gosford) all Mesozoic.
Hawkesbury Series	Narrabeen stage.	Upper part Triassic. Lower part Permian.	
	Newcastle Series.	*Permian.*	

Similar contradictions have no doubt come to the notice of others and one could easily multiply instances by a search through the literature.

(*b*) *The Lower Gondwanas of India and Australia.*—But perhaps the most remarkable example of the kind we owe to that distinguished geologist W. T. Blanford, who was perhaps the foremost amongst the several able men who during the latter half of last century laid the foundations of geological science in this country. After many years' intimate experience of the fossiliferous formations of India, and particularly of the Gondwanas, his deliberate opinion was that 'the Gondwana beds from top to bottom are of unusual interest on account of the extraordinary conflict of palæontological evidence that they present'. And he went so far as to say that if the plants were to be relied upon in the same way as the animals, then we would have in India 'a Rhætic flora overlying a Jurassic flora, and a Triassic fauna above both', and in Australia 'a Jurassic flora associated with a Carboniferous marine fauna, and overlaid by a Permian freshwater fauna' (*Rep. Brit. Assoc.*, 1884; *or Rec. G.S.I., 18*, p. 32 ff.).

The words I have just quoted were addressed to the geology section of the British Association at Montreal in the year 1884. They present to us in a nutshell the kind of attitude that geologists once held towards fossil plants as an aid to stratigraphy. Blanford's address was mainly devoted to an exposition of the many pitfalls that were then believed to lie in the path of the unwary geologist who might be tempted to employ fossil plants as a guide to stratigraphical correlation. To some of us

[1] Although palæobotanically the lower part of the Narrabeen stage cannot be separated from the underlying Newcastle series which is definitely Permian (*Sahni*, 1926, p. 245).

here to-day he may seem to have overstated the case. But we must remember that he was speaking a little over 50 years ago, when the prolonged and bitter controversy over the age of the Gondwanas had already come to a peak. From that controversy some of the foremost palæobotanists in Europe had come out with their colours lowered. McCoy and De Zigno, Saporta and Schimper, Carruthers and Bunbury, had all regarded our Damuda flora, and its Australian correlative the Newcastle flora, as Jurassic. The unfortunate fact was that in 1879 Schmalhausen (*Beitr. z. Juraflora Russlands., Mém. Ac. Sci. St. Pétersb.*) had assigned to the Jurassic an important collection of Russian plants which (as subsequent events showed) had come from mixed horizons, partly Jurassic, partly Palæozoic. A few of our Damuda plants had been identified and others closely compared with members of this supposed Jurassic flora, which also included tongue-shaped leaves recalling *Glossopteris* and *Gangamopteris*; and by some inexplicable process the whole of our Damuda flora was swept into the Jurassic net! The nearest resemblances were supposed to lie with the Lower and Middle Jurassic floras of Europe and here the superficial resemblance between *Glossopteris* and *Sagenopteris* must have helped in the deception. Feistmantel, it is true, had upheld an older age for the Damudas: he had classed them as Triassic but, as we know, even he had not gone far enough. Meanwhile the animal evidence in favour of a Permian age had become invincible.

I should imagine that fossil plants were never so much at a discount among stratigraphers as they were about the time Blanford wrote. No wonder that to a more or less marked degree geologists all over the world had a mistrust of plant remains. But in India this was a special pity because such a large proportion of our fossiliferous strata are freshwater deposits with plants as the chief basis for correlation.

Only gradually were the doubts cleared away. One after another were found, in distant countries like Brazil, South Africa and Australia, those few but sure links with the northern floras that we have learnt to value so much. And now we can say that, like the animals, the plants show our great southern coalbearing series to be Palæozoic. There never was any real discrepancy.

(*c*) *The Laramie problem* (*U.S.A.*)—American geologists are familiar with the long controversy over the Laramie problem, only recently laid at rest.

The question was whether the Cretaceous-Tertiary boundary line was to be drawn below or above the Laramie formation.

TABLE

(summarizing the Laramie problem).

WASATCH (Undoubted Tertiary)	
FORT UNION Fauna very distinct from Laramie (no Dinosaurs); but flora regarded as closely allied to Laramie.	
LARAMIE (in its eastern part known as the LANCE) Cretaceous fauna with Dinosaurs throughout but flora of modern aspect, regarded as Tertiary.	CANNONBALL marine member interstratified with the LANCE. Rich fauna of strong upper Cretaceous affinities.
Undoubted marine Cretaceous.	

The Laramie, in its eastern part known as the Lance, is a thick freshwater series containing a Cretaceous fauna with Dinosaur bones throughout, but also a flora which the early palæobotanists had pronounced Tertiary. The contradiction between the flora and fauna thus lay within the Laramie itself. Below the Laramie lie undoubted marine Cretaceous beds. Above it is the Fort Union formation with a flora reported to be closely allied to the Laramie but a very different vertebrate fauna devoid of all trace of dinosaurs (see Table).

If we go by the plant remains the Laramie and Fort Union should both be classed as Tertiary, and indeed in many places there seems to be a conformable passage between them. If, on the other hand, we give prime importance to the animal remains the Laramie (and Lance) are Cretaceous, the Fort Union is Tertiary; and this view is supported by the recent discovery (1922) of the Cannonball marine beds in N. Dakota which are interstratified with the Lance formation and contain a well developed fauna of undoubted Upper Cretaceous affinities.

Geologists in America now seem agreed to draw the line between the Laramie and the Fort Union formations, thereby giving greater weight to the faunal evidence, which obviously is very strong. A critical comparison of the two floras is therefore indicated to see if after all they do not fall into line with the faunas.

(*d*) *The Deccan Trap.*—A problem in some ways parallel to the Laramie was that of the Deccan trap formation which also turned upon the position of the Cretaceous Tertiary boundary line. The whole question was discussed at length at our Hyderabad meeting last year (*Proc. 24th Ind. Sci. Congr.*, 1937, pp. 459–471). So I shall content myself here with a reference to the salient points, so far as they concern the supposed conflict between the plant and the animal evidence.

The Deccan traps are a thick series of volcanic lavas covering an enormous area in the Indian peninsula. Direct evidence regarding their age is afforded by the flora and fauna of the so-called Intertrappean beds, an intermittent series of freshwater deposits laid down in lakes and rivers during the quiescent periods between the eruptions. Indirect evidence is given by the fauna of certain beds below, above and in distant areas but the exact relations of these beds with the traps are not always clear. This much is certain that in the Central Provinces the traps overlie strata of known Cretaceous age, viz. the Dinosaur-bearing Lameta beds, and the Bagh beds which contain a marine Cretaceous fauna. For the rest the field evidence is not clear. Near the west coast some traps are stated to underlie beds of nummulitic (Eocene) age. Still further off, in western Sind, a trap flow is said to lie below the Eocene Ranikot beds and above the *Cardita beaumonti* beds which are generally regarded as late Cretaceous; but the exact relation of this trap flow with the lavas of the Deccan is unknown. On the east coast, near Rajahmundry, certain other basalts are said to be separated by an unconfirmity from underlying beds containing *Cardità beaumonti.* A general view of the situation is diagrammatically shown in the accompanying scheme (this should not be regarded as a geological correlation table).

Table showing the Deccan Traps and related formations.

Ranikot beds of Sind	Nummulitics of Western			
Trap.	cost Trap.	DECCAN	TRAP	Trap
		Lameta beds.	Bagh beds.	*Cardita beaumonti* beds of Rajahmundry.
Cardita beaumonti beds of Sind.				

These and other facts have been so often discussed that it is difficult for us today to keep an untrammelled mind on the matter.

The pioneer geologists of a century ago had judged the traps to be early Tertiary, and in this they were largely guided by the intertrappean flora which included, *inter alia*, the characteristic Eocene fossil *Nipadites*. Even the associated fauna was then regarded as Tertiary (*Hislop, 1860, QJGS XVI, p. 165*) so that at that time there was no question of a discrepancy between the flora and the fauna. In subsequent years fresh-water fossils, and particularly plants, fell into disfavour with geologists. Even the evidence of the fauna does not then seem to have been taken seriously, and the question of the age of the Deccan Trap was again thrown into the melting pot. The direct evidence having thus been rejected as unreliable, there remained only a variety of indirect considerations, based partly upon dubious field evidence, partly upon the testimony of the animals in the associated strata. Largely through the influence of W. T. Blanford these indirect data, although admittedly inconclusive, were allowed to override the direct testimony of the flora. Thus in 1867 Blanford lent the weight of his authority in support of the Cretaceous theory. Before long this was adopted as the official view of the Geological Survey of India (*H. B. Medlicott and W. T. Blanford, Manual of the Geology of India, 1st ed., 1879*) and this has been for many years the view generally accepted by geologists both here and abroad. From time to time during the past sixty or seventy years attempts were made to revive the Tertiary view, notably in 1871 by T. Oldham (*Rec. Geol. Surv. Ind., IV, p. 77*), in 1884 by P. N. Bose (*see Proc. 24th Ind. Sci. Congr., 1937, pp. 461, 463*), in 1908 by Smith Woodward (*Mem. Geol. Surv. Ind., Palæont. Ind., III, pp. 1–6*) and more recently by others. But the faith of the Geological Survey in Blanford's judgment remained unshaken and in 1926 Sir Thomas Holland wrote (*Indian Geol. Terminology, Mem. Geol. Surv. Ind., LI, p. 88*): 'There can be very little doubt that the intertrappeans as a whole are Cretaceous, and this is very greatly strengthened by the occurrence of *Bullinus prinsepii* in the Mæstrichtian of Baluchistan'.

This was the position down to the end of the year 1933 when a comprehensive review of the intertrappean flora finally turned the balance again in favour of a Tertiary age, which apparently is now accepted by the Geological Survey. Not only were there individual genera of plants in this flora (*Nipadites*, *Azolla*, etc.) which strongly supported this view but the general character of the flora, with its great preponderance of palms, was distinctly Tertiary (*Sahni, Srivastava and Rao, The silicified flora of the Deccan Intertrappean series, Proc. 21st Ind. Sci. Congr., pp. 24–27, communicated Nov. 1933; Sahni, The Deccan Traps, are they Cretaceous or Tertiary, Current Science, Bangalore, III, pp. 134–136, Oct. 1934*).

In mentioning these details my main object is to emphasize that in fact there never was any real conflict between the plant and the animal evidence. We have seen that once it was decided that the plants were unreliable, the associated animals were thrown overboard with them, without any apparent reason. On the other hand, when the plant evidence reasserted itself, faith in the animals also revived. The whole history of this vexed question is an instructive example of the way in which the discrepancies, doubts and dissents of seventy years were dispelled once the evidence from one quarter became overwhelming. Not only did the animals on the whole support the plants but collateral evidence from radio-active data added its weight, while the field evidence educed by Blanford, never really convincing, now began to seem more dubious than ever. What is more, that oft-mentioned gastropod, *Bullinus* (*Physa*) *prinsepii*, so long ranked in India as a leading Cretaceous fossil, was now relegated to its real home in the backwaters of the Eocene.

(*e*) *The Po series of Spiti* is generally correlated with the Middle Carboniferous, and the grounds advanced for this are palæontological as well as stratigraphical. The greater part of this series, the *Fenestella* shales, contains a marine fauna presumably correctly assigned to the Middle Carboniferous, but geologists generally have ignored the fact that the basal part of the series, known as the Thabo stage, contains plants

which Zeiller had long ago compared with Lower Carboniferous forms. These plants have now been re-examined and their Lower Carboniferous affinities have been fully confirmed (*Gothan and Sahni, Fossil plants from the Po series of Spiti, Records Geol. Surv. Ind., 1938, LXXII, pp. 195–206*). So far as I know, there is no proved association of the flora and fauna in one and the same horizon, except that one rolled pebble which contains a well preserved leaf of *Rhacopteris ovata* McCoy sp., is said to have been collected from the *Fenestella* shales. The source of this pebble being doubtful, it would be wrong to assert that the flora and fauna co-existed in the Po series. There is thus no real contradiction between the two sources of evidence for the simple reason that they refer to distinct horizons in the series, and the plant evidence has since been supported on other grounds (*Fox, The Gondwana system and related formations. Mem. Geol. Surv. Ind., 1931, LVIII, p. 193*).

The Upper Gondwanas of India are generally subdivided into the Rajmahal, Kota, Jabalpur and Umia stages, exposed in widely distant parts of the country. It is generally assumed that the order in which they are named is based upon the affinities of their floras. This was no doubt the sequence originally suggested and it may be the correct sequence, but until all the floras have been critically revised the question cannot be regarded as closed.

Feistmantel had included all the four stages in the Jurassic. But in two cases (the Umia beds in Cutch and the Madras Coast beds) a conflict has arisen between the age as suggested by Feistmantel on the basis of the flora and that indicated by the marine fauna of associated beds. In both cases the animals indicate a younger age.

(*f*) *The Umia beds* are now considered younger than Jurassic because they are said to be interstratified with beds containing a marine fauna homotaxial with the Wealden. But the flora has never been revised since Feistmantel's time and all one can say is that so far it has revealed no characteristic Wealden species. Some further collections still await examination, and it is possible that the recent discovery of *Weichselia* and *Matonidium* in the neighbouring area of the Idar State (*B. Sahni, 1937, Rec. Geol. Surv. Ind., LVI, p. 152 ff.*) may be extended into Cutch. However, till the flora and fauna have been equally well explored it would be wrong to assert that there is any conflict of evidence.

(*g*) In the *East Coast Gondwanas* Dr. L. F. Spath claims to have discovered Lower Cretaceous ammonites and he suggests that the associated plant beds must be of a similar age. In doing this he revives a hint thrown out long ago (*Manual, Geol. of India, 2nd ed., 1893, p. 208*) that not only the Madras beds but even the Rajmahals may be younger than Jurassic. I do not know if Dr. Spath's evidence is of a conclusive nature, but no palæobotanist would contest it unless he knew that the flora contains a sufficient number of leading Jurassic forms, which is not the case. As the flora still needs a critical revision, it would be rash to assert that there is any real discrepancy.

But however justified Dr. Spath may be in referring the Madras coast gondwanas to the Lower Cretaceous there is certainly no ground for doing the same with the Rajmahal flora. This flora is now too well known, and contains too many forms directly comparable with Jurassic ones in other parts of the world, to admit of its being classed as Cretaceous. One cannot say the same of the Jabalpur beds of which the flora is not so well known and which also Dr. Spath refers to the Cretaceous. If, however, the Rajmahal flora is seriously regarded as Cretaceous then here, at last, we have a real conflict between the testimony of the plants and that of the animals. But is it safe to apply conclusions based upon the imperfectly known fauna of one region to the well known flora of another situated over a thousand miles away?

Sources of Error.—These few examples may suffice to show that the supposed discrepancies are in most cases due to our own mistakes. The sources of error are familiar to us all: imperfect collecting; wrong deter-

mination of species (often due to poorly preserved material); collections from mixed horizons being considered as one flora or fauna; conclusions drawn from one area or geological horizon being extended to distant areas or strata whose relations are not fully known; homœomorphic forms being considered as identical.

The responsibility of some of these sources of error is clearly established. Schmalhausen's supposed 'Juraflora Russlands' was a mixed assemblage from strata ranging in age from Palæozoic to Jurassic. We can scarcely say even today that we have completely got over the effect of this classical blunder. In the Po series there is no actual association of Lower and Middle Carboniferous forms, yet the age of the series as a whole was assessed solely on the preponderating fossil element, namely the marine animals in the Fenestella shales, in disregard of the flora in the basal part of the series.

Agreement as to what constitutes a 'species' is difficult enough to achieve in dealing with living forms; with fossil material it must be even more difficult. For stratigraphical purposes a narrower concept of 'species' is preferable to the wider. The use of comprehensive species ranging in their different component forms through a long geological period tends to prevent a classification of strata into chronological zones or ecological facies.

For a long time it has been commonly believed that marine animals are a better index of age than land plants, and the reasons for this view are well known. It is true that in several formations, e.g. the Jurassic, the flora appears more or less uniform through a long range of time whereas the same interval elsewhere is minutely zoned by marine animals. But it is important to enquire how far this fact is due to the inherent unfitness of plants as zone fossils and how far to our own lack of critical knowledge of the diagnostic features of plant-remains. At least so far as the Carboniferous is concerned the work of the Heerlen Congress has given ample proof of the value of plant remains in a zonal classification of rocks. Indeed, in a recent paper Professor Jongmans, to whom most of the credit for organizing this work is due, has even expressed the view that plants may sometimes afford a more satisfactory basis for correlation than marine animals (*Jongmans, Palæobot. Unters. i. Oesterr. Karbon. Berg- u. Hütt. Monatshefte, 1938 Bd. 86 Heft 5, p. 97*).

The fragmentary nature of plant-remains has frequently been urged against their employment in stratigraphy. But I venture to suggest that this very drawback places the student of fossil plants in a position of vantage over the palæozoologist. My point is that for each true species of large plants, such as a fern, cycad or conifer the palæobotanist often has two or three, sometimes four or five, artificial species to serve him as stratigraphical guides.

The fragments may be difficult to piece together and we may be a long way from gaining a picture of the plant life of the period. But here we are not concerned with that aspect. *So long as we know the fragments specifically, each of them will have the same age value as the complete plant.* To the stratigrapher it matters little whether a *Glossopteris* frond belonged to a *Vertebraria*, a *Ptilophyllum* to a *Williamsonia* or a certain *Sphenopteris* to a *Lyginodendron* or a *Lagenostoma.* To him any definitely recognizable fragment known to characterize a bed is a stratigraphical index regardless of its botanical affinities, although of course a knowledge of its affinities may be, and often is, an additional help.

The great thing is that we must know our fragments, and it is in this direction that modern palæobotany has recorded some of its most striking advances, particularly in the study of cuticles and of spores, both of which, I believe, are destined to rank among the most valuable aids to chronology. As I said elsewhere this morning (*Pres. addr. botany section, Proc. 25th Ind. Sci. Congr., 1938*) the facility with which spores travel across space invests them with special importance as zone fossils: whether of local origin or blown from afar they are equally useful as age indicators. Many

strata once regarded as unfossiliferous are already yielding valuable stratigraphical material under the microscope. The future of micro-palæobotany as an aid to stratigraphy is thus fully assured.

2. Mr. D. N. Wadia, Calcutta.

Instances of discrepant testimony of plant and animal fossils in the correlation of Indian formations are :—

(*a*) The Po series of Spiti Himalayas—fossil fern like plants of Lower Carboniferous (Culm) age associated with a marine fauna of Middle Carboniferous age.

(*b*) The Agglomeratic Slate series of Kashmir—a Productid fauna, earlier than that of the Lower Productus Limestone, along with species of *Gangamopteris* and *Glossopteris* whose affinities may be with the Permian (Damuda) of East India.

(*c*) The Gondwanas of the East Coast—containing ammonites, described as of Upper Neocomian age, side by side with a fossil flora whose Middle Jurassic affinities are insisted upon by many observers, on the ground of its stratigraphic position as well as on the evidence of associated fish and reptilian remains.

(*d*) The Deccan Inter-trappean beds—containing a flora with a preponderance of Palms, (along with fossil fishes), indicating Eocene affinities, in the lower part of the traps of Nagpur, while the abundance of reptiles in the conformably underlying infra-trappean beds (Lametas) of adjoining localities indicates a Cretaceous age; the latter occurrence is in keeping with the Wealden flora (*Matonidium*, *Weichselia*) of the Idar sandstones forming the floor of the Lameta-Trap succession.

These discrepancies, except in the case of (3), it must be admitted, are of comparatively minor significance and can probably all be accounted for by the accidents of collecting of the fossils, the varying conditions of sedimentation, bad preservation, etc. There is also the important consideration of a lag in the rate of evolution of plant and animals in distant quarters of the earth and the possibility of the association of a Middle Jurassic land flora with a Lower Cretaceous marine fauna in some secluded and barricaded terrestrial area. Stratigraphic data, carefully collected in the field, should be given prime importance in dealing with cases of discrepant testimony of plant and animal fossils in a stage or series.

3. Dr. M. R. Sahni, Calcutta.

Are there discrepancies between the evidence of plant and animal fossils?

Absolute synchronism between the minor subdivisions of the geological scale cannot always be expected in the case of strata in widely separated regions, but whenever fossils have been reliably identified, the palæobotanical and palæozoological data mutually support, and do not conflict with, each other. At any rate the discrepancy is not greater than sometimes exists in the case of certain formations correlated on the basis of animal or plant fossils alone. For example, according to Dr. Spath (*Meddelelser om Grönland, LXXXIII, p. 79, 1930*)—

> 'It is even possible that the *Ophiceras* layer of Pastannah in Kashmir is not synchronous with the zone of *Ophiceras tibeticum* at Painkhanda, for the commonest ammonite of the *tibeticum* zone of the Himalayas was very rare in Kashmir.'

And yet the synchronism of the *Ophiceras* beds in different regions is accepted. The discrepancy here is, I think, easy to explain if we remember that we may be correlating younger with relatively older horizons *within the same zone* or *vice versa*. A zone may be represented by twenty feet of

strata in one locality and only two in another. Even making allowance for the assumption that the rate of depositon may be slower in some than in other regions, we can hardly assert that the two feet of strata in one locality span an equal period of time as the twenty feet in another, in spite of the presence of the same zonal fossil in both.

Thus the *Ophiceras* beds of one area may, but need not necessarily, be absolutely synchronous with the *Ophiceras* beds of another area.

To give an instance of even more serious conflict, the equivalents of the Namyau series, which have been regarded as Upper Jurassic on palæontological evidence by various writers, including the present (*Rec. Geol. Surv. Ind., 71, Pt. 2, pp. 217–230, 1936*), are assigned, likewise on palæontological evidence, to the Upper Trias by the French geologists in Indo-China (*M. Fromaget: Bull. Surv. Geol. Indocohine, XVIII, Fasc. 5, pp. 19-20, 30, 1929*). The discrepancy covers practically a whole system. It is in my opinion the result of misidentification of fossils and of insufficient evidence. Yet, in fairness to the palæontological record, it must be said that where such evidence is complete, the faunas are remarkably similar, even in distant regions. I think no more striking instance could be cited than that of the *Calceola sandalina* zone faunas of Eiel and Padaukpin (Northern Shan States) which, separated by 90° of longitude and 35° of latitude, are unquestionably identical. This is due to the fact that the faunas in these regions are exceptionally well-preserved, prolific and therefore reliably identifiable. Undoubtedly palæobotanists can cite similar instances in their plant record.

The conclusion is that the existing discrepancies are not inherent in the available evidence but are due to the imperfection of the geological and palæontological or palæobotanical record or to the interpretation thereof. They are based upon premises and determinations which cannot always be accepted without reserve, and I shall endeavour to illustrate this with reference to three important Indian formations—the Deccan Trap, the Gondwana rocks and the Po series.

1. The Deccan Trap.

In dealing with the Deccan traps many of the arguments advanced in favour of their Tertiary, or against their Cretaceous age, will necessarily have to be reiterated, but I shall hope to do so from a slightly different angle to the arguments generally advanced.

Palæontological evidence in favour of a Cretaceous age examined.

(a) *Physa (Bullinus) prinsepii.*—

An important factor in assigning a Cretaceous age to the traps is the occurrence of a supposed *Physa (Bullinus) prinsepii* in the Cretaceous rocks of Baluchistan, it being the leading fossil of the intertrappean beds in the Deccan. My brother Prof. B. Sahni, attaches little importance to the evidence of this fossil from Baluchistan (*Proc. 24th Ind. Sc. Congress, General Discussion. The age of the Deccan Trap, p. 466, 1937*). Although I am in agreement with him in his conclusion, my reasons for doing so are different.

This is the only record of this species in Cretaceous strata, and has been used by Sir Thomas Holland in favour of the Cretaceous-age-theory for the traps. He writes:

> 'There can be very little doubt that the intertrappeans as a whole are Cretaceous, and this is very greatly strengthened by the occurrence of *Bullinus prinsepii* in the Mæstrichtian of Baluchistan'. (*Mem. Geol. Surv. Ind., LI, p. 88, 1926*).

In reading the account of the circumstances under which the Baluchistan specimens were recorded, I feel convinced that their identifica-

tion by Vredenburg (*Rec. Geol. Surv. Ind., XXXV, pp. 114–118, 1907*) is extremely doubtful.

This fossil was collected by Noetling, yet Noetling himself does not mention this important occurrence in two accounts which he wrote of the stratigraphy and palæontology of the Des Valley, whence the supposed *Bullinus* was reported to have been collected (*Gen. Rept., Geol. Surv. Ind. for 1898-1899, pp. 51–63, and Centralblatt für Min. Geol. und Pal., for 1903*). Noetling gave lists (incomplete according to Vredenburg) of the fossils collected by him, and it would indeed be remarkable if the most important fossil had escaped Noetling's critical eye. Furthermore, Vredenburg remarks upon the small size of the specimens from Baluchistan, as compared with the normal type found in the intertrappeans. Nor does Vredenburg figure this important find, and all my efforts to trace the specimens in our Museum collections have been futile, although other specimens from this locality were registered and may be seen in the Geological Survey collections.

In the circumstances I think that this identification cannot be accepted and the occurrence of an undoubted *Bullinus prinsepii* of the intertrappean beds, in Cretaceous strata, has yet to be demonstrated. The specimens from Baluchistan may belong to some diminutive species of *Bullinus* or to some closely allied genus.

An important argument in favour of the Cretaceous age of the trap, therefore, falls to the ground. At the same time the value of the association of this species with Tertiary plants is enhanced, thus obviating the supposed discrepancy.

(*b*) *Cardita beaumonti.*—

We may now examine the evidence of another important fossil, *Cardita beaumonti.* This fossil occurs interstratified with the lava flows of Sind. The Cretaceous age of the main Deccan Trap was based on an unwarranted assumption, that the Sind traps represent the youngest and not the oldest flows. Moreover, there is still doubt whether this supposed flow is not in fact a sill. Since the *Cardita beaumonti* beds rest both above and below the trap (?) it was assumed that the whole of the Deccan trap must be of Cretaceous age. This assumption is undoubtedly influenced by the fact that these beds are overlain by Eocene rocks. Sir Thomas Holland (*Mem. Geol. Surv. Ind., LI, p. 64, 1926*) states on the authority of Vredenburg (*Rec. Geol. Surv. Ind., XXXV, 180, 181, 186, 1908*) that

> 'In geological age the Deccan traps range from soon after the formation of the Lametas (*cf. C. A. Matley, Rec. Geol. Surv. Ind., LIII, p. 162, 1921*) of about Cenomanian to Aptian age up to the end of the Cretaceous epoch, basalt flows in Sind being found between the *Cardita beaumonti* beds of Mæstrichtian age and below Lower Eocene beds.'

It should be borne in mind that a fossil gives the age of the containing bed only, not of what lies above or below it, or in other areas. Therefore if we can be sure of one thing, it is that the trap in Sind (assuming that it is not a sill) is of Danian and pre-Ranikot age, but it does not enable us to establish its position with reference to the main trap of Central India, that is, whether it is contemporaneous with the oldest or youngest flows of the latter. *Moreover Cardita beaumonti has not been found associated with any fossils, plant or animal, which are confined to the Tertiary. We can therefore state that just as the association of Physa (Bullinus) prinsepii with a Cretaceous fauna has not been demonstrated so also the occurrence of a definitely and exclusively Tertiary fauna or flora with Cardita beaumonti has not been established.* The evidence of *Cardita beaumonti* does not therefore prove a discrepancy. But palæobotanists will have to admit that volcanic activity, as pointed out by Prof. L. Rama Rao (*Proc. Ind. Acad. Sc., IV, No. 3, Sec. B, p. 219, 1936*), had already

begun in independent centres, in Western Sind and Rajahmundry, about the close of Cretaceous times.

The foregoing arguments may, however, be regarded as more or less negative evidence. But Hislop has, in no mistakable terms, expressed his opinion in regard to the age of the intertrappean fauna, both vertebrate and invertebrate, as well as the flora. He compares certain intertrappean fossils with those from the Nummulitics of Western India, and species of *Turritella, Natica, Physa, Vicarya* and *Cerithium* wih those from the Eocene deposits of Europe. *If, then, we accept his conclusions, the occurrence in the same bed of the species Physa (Bullinus) prinsepii, Paludina normalis and the plants Chara malcolmsonii and C. elliptica, pointed out by Hislop (Q.J.G.S., XVI, p. 165, 1860) obviously discredit any idea of conflict between the plant and animal evidence. Had* we found *Chara* or *Nipadites* or a profusion of palm-wood in beds interstratified with the *Cardita beaumonti* beds, there would be evidence of conflict between the plant and animal evidence, but as far as I know, no such record has been found.

It is true, W. T. Blanford remarks that

> 'there are some strong resemblances between some of the fossils of the Rajahmundry intertrappeans and those of the Cretaceous beds of Trichinopoly.' (*Mem. Geol. Surv. Ind., VI, p. 24 (= 160), 1867*).

But the phrase 'strong resemblances' does not seem convincing to the writer who has not seen any systematic comparisons of species by Blanford, which Hislop has given in detail. The same importance cannot therefore be attached to Blanford's opinion as to Hislop's. Unfortunately when Hislop wrote, the fauna of the Cretaceous of South India had not yet been described (*Blanford, loc. cit. footnote, p. 24*) and Hislop himself has not been able to express an opinion on Blanford's comparisons referred to previously.

The evidence of the two leading animal fossils and of the other fauna, therefore, does not conflict with that of the fossil plants. Indeed, the evidence of one of these, *B. prinsepii* even supports that of the flora, for it is one of the commonest fossils associated with the intertrappean plants of known Tertiary age.

Geological, not palæontological, arguments mainly responsible for supposed discrepancies.

Discordance between the Trap and the Infratrappeans.—The purely stratigraphical evidence brought forward by W. T. Blanford (*Mem. Geol. Surv. Ind., VI, pt. 1, Chap. 9, p. 51, 1869*) in support of a Cretaceous age for the Deccan trap is that there is no great break between these and the underlying formations. King (*Mem. Geol. Surv. Ind., XVI, p. 52, 1880*) expresses himself in similar terms:

> 'the traps do not appear to be disassociated from the Infratrappean beds ..... to such an extent of unconformity as the supposedly Upper Eocene age of the intertrappean beds would require.'

While it may be true that the discordance in dip between the two formations is not great, in the face of the plant and animal fossil evidence it can hardly be suggested that the traps are Cretaceous. It may well prove or, at least, lead us to suspect that the age of the Bagh beds is probably younger than we are accustomed to assign to them. Indeed certain fossil specimens from the Bagh beds, kindly given to me for identification by Mr. P. N. Mukherji, do indicate a higher horizon for them. Amongst these are *Protocardium pondicherriense* D'Orb. *Cardium (Trachycardium) incomptum* (Sow.), *Macrocallista sculpturata* (Stoliczka) and *Turritella (Zaria) multistriata*, which are characteristic of the Upper Cretaceous of Southern India. On their evidence the Bagh beds may range well into the Upper

Cretaceous instead of being referred only to the lower part of the Upper Cretaceous, as thought hitherto. In further support of this I may mention that von Huene and Matley assign an Upper Cretaceous age to the Lametas (fossiliferous sedimentary type), which are supposed to be the terrestrial equivalent of the Bagh beds.

In this way it has been possible to reconcile the absence of a major discordance with the fossil evidence and thus, at the same time, the supposed gulf between the plant and animal evidence is bridged.

In passing I may mention a fact of great importance, namely, that the Bagh species just referred to are characteristic of the South Indian Cretaceous. It may therefore well be that the land mass which is supposed to have separated the South Indian Cretaceous sea from the Bagh sea was not a permanent feature during the Cretaceous period, and that it was submerged during periods of marine transgressions. As more fossil evidence accumulates, greater affinity between the faunas of the two regions will, in my opinion, become evident.

The geological argument has been used again by Blanford (*Mem. Geol. Surv. Ind., VI, p. 22 (= 158) 1867*) in the case of the traps at Surat. He states:

> 'the lower eocene beds of Surat rest quite unconformably upon the traps, and there is clear evidence of an enormous amount of denudation of the latter both before and during the deposition of the Nummulitic sea.'

It is apparent that this argument cannot be treated as establishing the Cretaceous age of the main trap. It only proves that the trap at Surat is pre-nummulitic, but it does not prove that the whole of the Deccan trap is likewise pre-nummulitic.

In the case of the intertrappeans of Rajahmundry Messrs. S. R. N. Rao and K. S. Rao (*Rec. Geol. Surv. Ind., 71, Pt. 4, p. 391, 1937*) find that

> 'Typical cretaceous forms like *Pseudotextularia, Gumbelina* and *Globigerina cretacea* are either very rare or altogether absent. On the other hand forms like Orbitoideæ and Nummulites typical of the warm seas of the Eocene age are also absent. According to data now available the evidence of the forminifera seems to be in favour of using the name Palæocene.'

Treating the Rajahmundry trap as constituting an independent centre of vulcanicity, and without assuming that they are the youngest and not the oldest traps, the fossil evidence of their intertrappean beds does not in any way conflict with the palæobotanical evidence.

Direct animal fossil evidence supports plant evidence.

Conclusions of Hislop, Smith-Woodward and others.—From the foregoing one may conclude that wherever the fossil evidence is reliable or sufficient, the plant and animal evidence support each other. The palæontological work of Hislop, Smith-Woodward (*Pal. Ind., N.S., Vol. III, 1908*) and others is confirmed by the palæobotanical work published in recent years, which in itself discredits any idea of discrepancy. Discrepancies have arisen where attempts have been made to draw conclusions from purely geological considerations.

II. The Gondwana Rocks.

The evidence of vertebrate and plant fossils.

The Maleri stage.—There is apparently a serious discrepancy between the evidence of plant and animal fossils in regard to the age of the Maleri stage, for the vertebrate fauna consisting of *Parasuchus, Hyperodapedon,*

Belodon, etc. indicates Triassic affinities, whereas the plant remains, supposed to have been collected from the same horizon, indicate an Upper Gondwana age. But there has always been considerable doubt whether in fact the vertebrate and plant fossils were found in the same horizon.

Professor B. Sahni wrote:—

> 'It is important to ascertain beyond doubt the source of these plants, for if they were really from the Maleri beds, this fact would constitute the strongest evidence for a post-Triassic age'. (*General Report for 1928, Rec. Geol. Surv. Ind., LXII, p. 28, 1929.*)

Later Dr. C. S. Fox remarked that—

> 'If we remember that the correct horizon of the plant fossils from Chirakunt and Naogaon in the Jamgaon Valley has not been satisfactorily settled (although King's map suggests a Maleri horizon), it is evidently true that plant fossils have not been found on the same horizon (red clays) as the reptilian remains of Maleri'. (*Mem. Geol. Surv. Ind., LVIII, pp. 155-156,* 1931.)

From the uncertainty attaching to the horizon of the plant fossils it is clear that their evidence should not be treated as creating a discrepancy. I consider that the evidence of the vertebrates is conclusive in the present instance, and that the plants probably come from a higher Upper Gondwana horizon. In any case fossil records concerning which there is obvious doubt should not be regarded as evidence of discrepancy.

The Upper Gondwanas of the East Coast, etc.—A much more serious position has arisen in regard to the age of the Upper Gondwanas in view of Dr. Spath's identification of certain cephalopods found in the Upper Gondwanas of the East Coast. These formations which, on the basis of their plant remains, were hitherto assigned to the Jurassic, are now assigned to the Lower Cretaceous on the evidence of the cephalopods.

Dr. Spath has not confined his views as to age to these, but has extended them to include the Gondwana rocks of other areas. He writes:—

> 'Moreover, there does not seem to be any essential difference between the faunas of the lowest Budavada beds (Rajmahal Group) and those of the Ragavapuram shales or Sripermatur group of the Middle (Kota) series. That is to say the marine bands in these two series of the Upper Gondwanas, whether in the Godaveri District or near Madras, are already of Upper Neocomian age and the correlation of the still higher Tripetty and Jabbalpur series with the Umia group of Kachh is thus altogether erroneous'. (*Pal Ind., N.S., Vol. IX, Mem. No. 2, p. 827, 1933*).

The age of the other Upper Gondwana rocks, according to Dr. Spath, must be raised, likewise, to at least Lower Cretaceous. Yet on the basis of the plant fossils these have been assigned to some horizon or other of the Jurassic. Not only that, Dr. Cotter (*Rec. Geol. Surv. Ind., XLVIII, p. 27, 1917*) states—

> 'The age of the Kota deposits is not in dispute. It is generally admitted that the flora is later than that of the Rajmahal stage, but older than the Jabbalpur. The fish remains of Kota point to an age not earlier than Lias. The marine fossils found together with a Kota flora at Ragavapuram (*Macrocephalites, Trigonia interlævigata*) point to a Lower Oolite age.'

There is thus conflict not only between the recent palæozoological evidence and plant evidence, but also between the palæontological evidence as put forward by Dr. Spath and Dr. Cotter. The only conclusion that can be drawn is that we are either dealing with heterochronous formations

or that some of the determinations must be provisional. The flora of the East Coast Gondwanas is admittedly small, and I do not know how far it can be compared with the Upper Gondwana floras of other areas. Similarly the cephalopods identified by Dr. Spath are either new species or poorly preserved and not easily determinable forms, but I am not using that as an argument against their Cretaceous age. Their probable Cretaceous age had in fact been postulated long ago by Stoliczka from an examination of certain ammonites (*Pal. Ind. Ser. IX, Vol. I, 1875, p. 236; see also Pal. Ind. Ser. II, Vol. I, p. 223, 1880*). Their evidence, however, is directly opposed to the evidence of the *Macrocephalites* and *Trigonia interlævigata* identified by Dr. Cotter which, as already stated, are Jurassic forms.

Recently the writer, during the course of examination of the marine Jurassic of the East Coast Gondwanas, has come across one or two specimens which, as far as their state of preservation permits, must be referred to the genus *Rectithyris* Sahni. In Europe this genus is confined to the Cenomanian and occurs doubtfully also in the Turonian. It is found in the South Indian Cretaceous at the same horizon, viz. Cenomanian, as in Europe. While it is not suggested that the East-coast Gondwanas are so high up in the sequence, the occurrence of the genus *Rectithyris* is significant. The absence of other South Indian Cretaceous types in this area is an anomaly which may probably be explained upon a difference in the horizons of the beds containing the *Rectithyris* in the two areas.

In view of the foregoing I can only say that a thorough revision of the Gondwana floras and of the faunas of their marine bands is called for before we can definitely prove any semblance of conflict between the plant and animal evidence. It is obvious that the Upper Gondwana system is a composite of heterochronous formations, that there are many faunal and palæobotanical gaps in the sequence, and that the main responsibility for the conflict of evidence rests on these breaks, physical and physiological.

The responsibility therefore rests not upon the fossils, plant or animal, but upon the imperfection of the geological or palæontological record or in its interpretation. With greater and more reliable evidence, the gulf that apparently separates plant and animal evidence will be, in the writer's opinion, bridged over.

III. The Po Series.

Apparent discrepancy.—In the case of the Po series again the discrepancy is due not to differences between the evidence of plant and animal fossils, but to two unfortunate circumstances, namely (*a*) an inadvertent mixing up of two fossil collections from different horizons resulting in incorrect correlation, and (*b*) assigning to *Protoretepora ampla* a much more restricted horizon than actually is the case.

The part of the succession in Sipti with which we are immediately concerned is as follows:—

Fenestella shales with *Protoretepora ampla* ..	Po series
Thabo stage	Po series
Syringothyris Limestone ..	Lower Carboniferous.

Although higher Permo-Carboniferous beds have been found, they do not contain *Protoretepora ampla* as in Kashmir, and this has an important bearing on the subject, as we shall see later.

The lower division of the Po series (Thabo stage) contains plant remains, *Rhacopteris ovata, Sphenopteris* sp., *Sphenopteridium furcillatum* Ludwig sp., etc. and was provisionally referred by Zeiller (*Mem. Geol. Surv. Ind., XXXVI, p. 47, 1904*) to the Lower Carboniferous. Recently Gothan and B. Sahni (*Rec. Geol. Surv. Ind., 72, Pt. 2, pp. 202-203, 1937*) have confirmed the probable uppermost Lower Carboniferous age of this sub-division, after a further examination of these plant remains.

In reading through literature dealing with the Po series and related formations, an important fact, which has apparently been completely lost

sight of, has emerged. It would appear that a younger age was assigned to the Po series on a palæontological correlation based on data which are manifestly incorrect, being due, as explained below, to an unfortunate mixing up of two faunas from entirely distinct horizons.

To understand this one must follow the complete succession of Palæozoic rocks at Zewan, in Kashmir:

Permian ..	Protoretepora ampla beds more Zewan series.
Permo-Carboniferous	Gangamopteris beds.
Upper Carboniferous	Panjal trap. Agglomeratic Slate.
Middle Carboniferous	Fenestella shales with doubtful *Protoretepora*.
Lower Carboniferous	Syringothyris limestone.

The admixture referred to was between the *Protoretepora ampla* fauna (Zewan stage) and the *Fenestella* shales of the Middle Carboniferous. The result was that the *Fenestella* shales of Spiti (*vide supra*) were correlated with the *Protoretepora ampla* beds (Permian) rather than with the true Fenestella shales (Middle Carboniferous), to which they correspond. As a consequence, a higher horizon was assigned to the Po series, including the *Rhacopteris* flora. I quote from Hayden (*Rec. Geol. Surv. Ind., XL, Pt. 3, p. 261, 1910*):—

> 'This correlation was based on a description by Professor Diener of certain fossil supposed to have been collected in beds of the Zewan stage, but Mr. Middlemiss has shown that they were a mixed lot derived partly from his Fenestella shales and partly from the true Zewan stage.'

Diener himself wrote (*Pal. Ind., N.S., Vol. V, Mem. No. 2, p. 106, 1915*):—

> 'The main mass of the Zewan beds, especially the zone of *Protoretepora ampla*, was even correlated by Hayden, directly with the Fenestella series of Spiti. This correlation which was based chiefly on the predominance of European Carboniferous types in Lydekker's collections, falls to the ground since the distinctness of the two faunas in Lydekker's fossil material has been brought to light by the geological researches of C. S. Middlemiss.'

Middlemiss himself correlated the whole of the Po series with the *Fenestella* shales of Kashmir on

> 'lithological, stratigraphical and on palæontological grounds' (*Mem. Geol. Surv. Ind., XL, Pt. 3, p. 225, 1910*),

apparently without taking into account the plant fossils.

Another factor which is responsible for the correlation of the *Fenestella* horizon of Spiti with the *Protoretepora ampla* beds (Permian) of Kashmir is that the former also contains this well known species, although the remaining fauna indicates a Middle Carboniferous age. Indeed doubtful *Protoretepora* occurs in the Fenestella shales proper of Kashmir and may possibly indicate that even in Kashmir *Protoretepora ampla* does not mark a very restricted horizon, but we cannot be sure of this till the doubtful *Protoretepora* has been specifically identified.

The Po series as pointed out by Hayden (*Rec. Geol. Surv. Ind., XL, Pt. 3, p. 262, 1910*) was—

> 'only very cursorily examined by the late Dr. Krafft and myself and may comprise fossiliferous horizons not yet found.'

Indeed the inference is that the *Protoretepora ampla* horizon of Kashmir, corresponding to the Zewan stage, is probably present also in the Spiti area, but has not so far been discovered.

The evidence of the fauna therefore points to one conclusion: that the original correlation was incorrect and that the *Fenestella* shales of Kashmir

correspond to the *Fenestella* shales of Spiti of Middle Carboniferous age, *but not to the whole of the Po series, as suggested by Middlemiss.*

The position then is that beds containing *Rhacopteris* are underlain by the *Syringothyris* limestone of Lower Carboniferous age (*vide supra*) and overlain by the *Fenestella* shales containing a Middle Carboniferous fauna. They must therefore be regarded as passage beds between the Lower and Middle Carboniferous. On the evidence of plants it is stated (*Gothan and B. Sahni, loc. cit., p. 202*) that—

> 'In Europe they would be assigned most probably to the Visé (upper part of the Lower Carboniferous).'

It is obvious that exact correlation between the minor stratigraphical subdivisions in widely separated regions cannot always be possible—even in the case of the marine faunas. In this connection the conflicting faunal evidence of another formation, the Zebingyi beds, is instructive and one may draw attention to it before reverting to a consideration of the *Rhacopteris* flora. In the Zebingyi passage beds of the Shan States we find both *Tentaculites elegans*, which in Europe is of definitely Devonian age, and certain graptolite species which are definitely Silurian. La Touche adopts what he calls the 'graptolite convention', which practically means that whatever the evidence of the other fauna, where Silurian graptolites occur the beds must be of Silurian age. (*Mem. Geol. Surv. Ind., XXXIX, p. 178, 1913.*)

Although the two cases are not altogether parallel, it is possible that the Thabo stage marks a position very similar (excluding the difference in age) to that of the Zebingyi beds, and if the *Rhacopteris* flora is Uppermost Lower Carboniferous in Europe, it could possibly be treated as a passage flora in India. This position practically bridges the gulf between the evidence of plant and animal fossils. It would be of interest to know what the evidence of such occurrences in the intervening regions between India and Europe would indicate, but apparently no such occurrence has been recorded.

Once more we come to the same conclusion, that such discrepancies as appear to exist are due to doubtful identifications (as in the case of the supposed *Physa* (*Bullinus*) *prinsepii* from the Cretaceous rocks of Beluchistan or to lack of adequate or properly collected material (as in the case of the aforementioned mixing of faunas from distinct horizons) or to drawing conclusions from purely stratigraphical data unsupported by fossil evidence, as in the case of the absence of a major discordance between the Bagh beds and the Deccan traps.

I am, therefore, of opinion that where reliable fossil evidence, whether plant or animal, is available, it should be accepted without reserve, and where the evidence is conflicting, a thorough re-examination of the fauna (or flora) is called for. It has been found that where discrepancies occur between the evidence or plant and animal fossils, the fossil data are invariably unreliable.

Do faunas and floras evolve at different rates ?

It has been suggested that under certain circumstances plants and marine animals may evolve at different rates—that marine organisms, owing to the uniformity of the environment under which they live, evolve more rapidly than terrestrial plants and that, as a consequence, newer marine types may be associated with older types of floras. While the association of a more modern fauna with one or two older types of plant fossils (or *vice versa*) may be possible on account of inherent tendencies which do not favour change among such persistent types, I do not think that a large scale occurrence of newer and older types of representatives of the two kingdoms has been established. The main thing to remember is that the conditions of preservation in the two great groups are entirely different, and that the apparent discrepancies may be due to imperfections

of the plant record. It is an admitted fact that if there is such a discrepancy in the case of the East Coast Gondwanas, where Lower Cretaceous marine types appear to be associated with Jurassic plants, the flora and even the fauna of these beds is far from well-known.

The conclusion then is that in all such cases of discrepancies a thorough revision of the faunas and floras is called for.

In the end the suggestion may be ventured that the geological section of the Science Congress would do a useful thing if they would form 'working committees' to take up the investigation of such crucial problems in hand and report on them at their meetings. Without a close collaboration between palæobotanists and palæontologists the presentation of such problems is likely to be one-sided.

4. Dr. T. W. Stanton, Washington.

I fear that my lifelong dependence on invertebrate fossils as the most reliable guide in the stratigraphy and correlation of Mesozoic formations would disqualify me as an unbiased judge of the question involved in the discussion.

No stratigrapher of this day, I believe, will question the statement that the most nearly complete stratigraphic record is found in marine sediments and that in general the succession of marine invertebrate faunas is fairly well determined. Continental sedimentary formations with their land floras, their vertebrate faunas, and their non-marine invertebrates must be interpolated in the marine sedimentary column by observation of the actual stratigraphic succession, where that is possible, and by interpretation of every available bit of structural, stratigraphic, and paleontologic evidence.

The title of the discussion raises the question whether the reported discrepancies between the testimony of plants and animals are real or only based upon erroneous determinations of species or erroneous estimates of their age values. I should say that it is most probable that some of the discrepancies are real. Land plants, terrestrial vertebrates, and marine invertebrates live under very different conditions and vary greatly in their ability to migrate quickly when living conditions change, or to adapt themselves to changing conditions without migrating. Changes that would seriously affect the environment of one of these classes might not greatly alter living conditions for other classes in the same area. It would be remarkable if the chapters in the history of land plants should exactly coincide in their beginnings and their endings with the chapters in the history of marine animals or even of the land animals of the same region.

The evidence seems to indicate that modern types were introduced somewhat earlier among plants than among animals. For this reason, in America at least, boundaries between systems and other major geologic divisions when based on the evidence of fossil plants are often placed somewhat lower than the faunal evidence would indicate. My lamented friend David White in discussing Permian floras (*Pan-Pacific Congress, Australia, Proc.*, 1923 (1924), vol. 2, p. 1038, 1926) speaks of the 'frequently remarked tendency to greater precocity on the part of the flora as compared with the fauna'. On the evidence of the flora he placed the lower boundary of the Permian in the Mid-Continent field several hundred feet lower than it had been drawn by others on faunal evidence.

While it may be true, as I have suggested, that there are inherent divergences in rate of development and other pertinent features that tend to prevent perfect agreement in age determinations based on different classes of fossils, I have no doubt that most of the discrepancies that have led to so much controversy in the past were caused by the lack of sufficient facts on which to base a sound judgment. If fossils are to be used in determining the age of a formation or stratum, the genera and species must, of course, be correctly identified, their stratigraphic range within

the area under discussion and elsewhere must be known, and there must be no doubt that they actually came from the formation or stratum whose age is in question.

The voluminous literature on the Cretaceous and Tertiary sedimentary formation in the Great Plains and Rocky Mountain areas of the United States is filled with discussions and controversies on the age of the plant-bearing and coal-bearing formations there widely distributed. The discussion began nearly 80 years ago when Meek and Hayden announced the discovery of dicotyledonous leaves in the formation now known as the Dakota sandstone. They knew that the formation could not be later than Cretaceous because they had seen a considerable thickness of marine Cretaceous strata overlying it. Drawings of some of the leaves were sent to Prof. Oswald Heer in Zurich for his opinion as to their age. He replied that comparison of the sketches (he did not have the fossils) with European fossil plants led him to believe that they were Tertiary and probably Miocene. Whether the Miocene age of the European standards of comparison was then well established I do not know, though I understand that the 'Arctic Miocene' which later received much attention has since proved to be in large part older than Miocene. The stratigraphic position of the Dakota sandstone was so easily demonstrated that its Cretaceous age was soon universally recognized. According to geologists who are acquainted with the overlying marine formations and their marine invertebrate faunas, the Dakota sandstone is not younger than late Cenomanian, though some paleobotanists think that its flora indicates Turonian.

The Laramie problem dates back about 70 years when Hayden's Geologic and Geographic Survey of the Territories, King's Survey of the Fortieth Parallel, and other exploratory surveys were active in reconnaissance studies of the geology of the western half of the United States. It was found that fields of coal and lignite are distributed over large parts of South Dakota, North Dakota, Montana, Wyoming, Colorado, New Mexico, and Utah and less extensively in Idaho—States with a total area of nearly 800,000 square miles. Additional great areas of the same coal-bearing rocks extend into the provinces of Canada adjacent to North Dakota and Montana.

Distributed over this vast area and through sediments aggregating many thousands of feet in thickness these coal-bearing rocks naturally did not form a stratigraphic unit, but they soon came to be treated practically as such and were known to many as the 'great lignitic series' or the Laramie formation. The early paleobotanists, such as Lesquereux, called them all Eocene, though he recognized slight differences in age in some of the fields. Other geologists acquainted with limited districts in which the evidence of earlier age seemed to them clear insisted that they are all Cretaceous. Neither group was right.

Gradually, as more refined stratigraphic and palæontologic studies, often accompanied by detailed areal geologic mapping, have been extended over a large part of the area it has been demonstrated that some of the coal-bearing rocks in question lie low in the Upper Cretaceous and are of Turonian or possibly even earlier age; that others are intercalated at intervals in the marine Upper Cretaceous column up to its very top as locally developed; that higher in the section the Fort Union formation contains a well-developed somewhat primitive mammalian fauna which the vertebrate paleontologists call Paleocene; that still higher coal-bearing rocks include the *Coryphodon* zone and associated zones with more highly developed mammalian faunas universally recognized as early Eocene; and that non-marine (fresh- and brackish-water) invertebrates, when discreetly used, may often serve as effective guides to stratigraphy and correlation.

In much of the area over which the Laramie was once such an insistent problem the question of the exact location of the Cretaceous-Eocene boundary is now confined to a few hundred feet of sediments, and there is

promise of an early amicable agreement based on a summation of evidence from all possible sources. When faunas and floras now known in the Upper Cretaceous and Eocene of the western interior region of the United States are all fully studied and described and the stratigraphic ranges of the species accurately recorded, North America will have a dependable paleontologic standard for stratigraphic classification and correlation of this part of the geologic column that may prove of world-wide usefulness.

5. PROF. T. D. A. COCKERELL, Boulder (Colorado).

Animals are in general much more complex organisms than plants, and thus they present more definite structures which may be identified in fossils, and usually evolve or change more rapidly than plants. Fossil plants are commonly known by the leaves or stems, the reproductive structures, as the flowers, being less often preserved. Animals are more motile than plants, and frequently the fauna of successive strata differ mainly in the presence of organisms which were actually contemporaneous with both, but had not reached the locality until the later rocks were laid down.

We have in Colorado two formations, the Green River Eocene and the Florissant shales, each containing very many preserved insects. Although there are some plants which seem to be common to both formations, or at least not distinguishable from the vegetative parts preserved, there are, so far as we know, no insects occurring in both. The Florissant beds are assumed to be Miocene and therefore much younger than the Green River. One of the main features of the Green River insect fauna whereby it differs both from that of Florissant, and from that of modern Colorado, is the presence of numerous prettily marked Fulgoroid Homoptera, looking like moths. Now such insects abound today in the Indian region. If the present fauna of India were fossilized and both it and the Green River beds were viewed from a time in the remote future an argument might well be made for the view that they were contemporaneous, though it would be entirely fallacious.

In the Pennsylvanian rocks (Upper Paleozoic) of North America are numerous plants and insects, the latter mostly cockroaches. The plants represent a fairly uniform flora but every insect horizon contains different species. This does not mean that the successive horizons necessarily represent so many successive stages in the evolution of these insects. It is probable that the differences are in large part due to migrations. Whatever the cause, however, the insects are certainly much more delicate horizon-markers than the plants.

One objection to the use of animals for stratigraphy is that the terrestrial species, at least, are not so often preserved, and hence their absence from the rocks does not mean that they did not exist. It is evident from the study of insect fossils that the leading modern genera were present in Eocene times, but frequently they are known by single specimens or wholly absent from collections made at various places and in various horizons. The fauna as a whole must be used in forming judgments, and single species or groups of species may be misleading. At Florissant, the numerous Bombyliid flies are all of extinct genera except two ; but the Asilidæ or robber flies from the same rocks, also numerous, belong to existing genera. There are many contrasts of this sort.

The rapid evolution of the mammals in Tertiary time is exceptional, and here we do have clearly discernible evolutionary sequences, often quite decisive for stratigraphy. But many creatures have become extinct at periods which can be approximately ascertained, and thus this presence is of value in determining that rocks are at least no younger than such and such a date. We can also use for dating purposes the arrival of animals in a new region, as migrants from Asia to America (such as the elephants) or from South America to North America (such as the sloths).

6. PROF. EDWARD W. BERRY, Baltimore.

Historically the standard geological time-table was a gradually built up patchwork of lithologic units or groups of units and usually a long time elapsed before they received a paleontologic basis. The major divisions or periods of time were at first the names of what we now call systems of rocks and geologists were slow to recognize that a system at its type locality always represented a shorter time than was connoted by the period which bore the same name as the system.

Stated another way it was the time breaks in sedimentation which bounded a system at its type locality which in the first instance enabled geologists to recognize it as an entity, but which subsequently occasioned most of our difficulties of correlation, when sediments were discovered in other regions representing the whole or part of the time that was not represented by sediments in the region where the name was first applied.

In addition our accepted scheme of geological chronology has certain handicaps due to the circumstances of birth. Historical or stratigraphical geology may be said to have passed through its infancy and adolescence in western Europe and it is certainly not a new thought to contemporary geologists that if it had grown up on any other continent it would not only have been a very different scheme taxonomically, but would probably have been a better scheme.

Looking back at the really great achievements of the founders of our science and without wishing to detract one iota from their well deserved renown, I ask the rhetorical questions, would anyone today think of going to Wales to study Cambrian history or even to the land of the Silures to get the best notion of Silurian history ? And if the concept of a Carboniferous system had grown up in Russia or the Mississippi Valley would we not have had a much more logical sequence ? Would there even have been a Jurassic system if geology had grown up in the United States ? I mention these things because it seems to me that they inevitably point to what the geology of the Indian empire shows so plainly, namely : that the syntheses of the so-called geological philosophers, with their cycles and epicycles of diastrophism and their rhythmic orogenies, are foredoomed when extended beyond provincial developments in an attempted world-wide application.

It was inevitable from the days of William Smith that the stratigraphic invertebrate paleontology would become the international standard, although most geologists would probably agree to what Lyell phrased so succinctly, that invertebrates were the hour hand, vertebrates the minute hand and plants the second hand of the geological clock. Marine sediments are so much more general in both time and space, are so much more favourable for the preservation of fossils and in general so much less liable to be destroyed by erosion, that it is quite futile to hope for a geological time-table based on other criteria that will be as useful or as usable.

Since, then, it is the succession of marine sediments and their contained faunas that are the basis of stratigraphic taxonomy, it follows that continental sediments which are the chief normal depositories of land animals and land plants will generally occur at the beginning or toward the end of our standard periods, or in the intervals between the marine sedimentation of the epicontinental or shelf seas.

Most of the controversial questions of stratigraphy have their origin in these circumstances. I may mention the Ozarkian, Hercynian, Permian, Rhætic, Wealden and Laramie as intersystemic problems of this sort, and there are innumerable ones of lesser magnitude involving formational boundaries.

It has been my experience that no group of organisms, either animal or plant, however conservative they may be, are without stratigraphic value or are discrepant with other groups. I well remember how useless for chronology Foraminifera were considered a generation ago, as a result of the long range broadly considered and variable forms of the Challenger

monograph. In recent years I imagine that commercial companies have paid more money to students of Foraminifera than to any other palæontologic specialists, whereas the close relatives of the Foraminifera, the Radiolaria, are but little used and are suspect, largely because they are a tool that no one has learned to use with stratigraphic precision. Diatoms are still considered of slight stratigraphic value but are proving to be of great value in the hands of Lohman of the U.S. Geological Survey.

Instances of this sort could be multiplied indefinitely. In the hands of an expert who knows both the words and the music any class of fossils will be found about equally serviceable. The tradition that plant fossils are inferior to animal fossils in precise chronology is based on a variety of circumstances not the least of which was the lack of understanding of some of its most conspicuous practitioners.

Another large factor was the contemptuous attitude of such outstanding systematic botanists of the floral morphology era as Bentham and Hooker. Much of the material for stratigraphic palæobotany and certainly the bulk that is sufficiently frequent in the geological record to be of any chronological service, consists of impressions or inclusions of detached parts, largely foliar. Quite obviously the impression of a sterile fern frond, or a cycad frond or an angiosperm leaf, is not in quite the same category as the shell of a brachiopod or an ammonite, or a skeleton of a reptile or mammal.

What is usually forgotten by critics of palæobotany, and this is especially the case in those horrible examples set forth by critical writers, of the similarity of diversely related modern plants, as if the poor paleobotanist had to choose between a calamite, an equisetum, a frenela, a casuarina and a polygonum, or between the leaves of 100,000 or more species of dicotyledons.

I venture to think that plant parts are quite as precisely recognizable as any other fossils even if it be conceded that they are identifiable with less certainty, and I would maintain that they would serve as handmaidens for stratigraphy about as well if they were numbered and remained unnamed, just as busy micropaleontologists in their commercial work frequently number instead of naming their horizon markers.

I do not mean to imply that the goal of palæobotany or even of stratigraphic palæobotany is on this low plane, and I would expect foliar features in general to be more conservative than most parts of the plant organism, and as having less selective value and hence less liability to change than floral or anatomical features. I may instance the ginkgophytes or cycadophytes as preserving their essential foliar features over eons of time. Certainly the cycadophytes have retained rather stereotyped foliar characters from the Carboniferous down to the present and during that time have shown great changes in stem anatomy and a still greater change in their floral morphology.

Palæobotany still suffers from the systematic optimism of a Heer or an Ettingshausen and from the habit of comparing fossil plants with pictures of fossil plants in the works of the founding fathers. When the palæobotanical riches associated with the late Cretaceous and early Tertiary coals of the western interior of North America commenced to flow into the hands of our American pioneer palæobotanists—Lesquereux, Dawson and Newberry, they identified many of them by the pictures in Heer's monumental work on the flora of the Swiss Miocene (so-called) or Heer's Arctic Miocene (so-called) and considered our so-called lignitic as Miocene. In the same way Lesquereux determined the first plants from the Wilcox group of south-eastern North America, the plants to which I have devoted so many years, as Miocene, although they are really lower Eocene.

The mistakes are not to be charged to the fossil plants, but to their interpreters. Quite early in the history of geologic exploration in our West when the boundary between Cretaceous and Eocene was being bitterly debated, the vertebrate palæontologist Cope advanced the idea that plant chronology was different from vertebrate chronology and that

what might be called the age of flowering plants started in the mid-Cretaceous, whereas the age of mammals started in the Eocene and it was implied that the flowering plants had undergone but slight changes since those far-off mid-Cretaceous days.

It is true that dicotyledonous leaves in some abundance appear in the record toward the close of the Lower Cretaceous and continue to the present, but they are at first associated with a large number of surviving genera that might be called Jurassic types, and many of these do not disappear until the close of the Upper Cretaceous.

In south-eastern North America which is strategically located at the gates of the American tropics, and whose Cretaceous and Tertiary land was a part of that larger segment of eastern North America which had been above the sea since early Carboniferous, there are abundant and well preserved floras throughout the Cretaceous and earlier Tertiary, which I have had the privilege of studying for the past thirty or more years. The uppermost Cretaceous in this region with prolific marine faunas is the Ripley formation which in clay lenses formed in coastal lagoons along the Ripley coast has furnished 135 species of fossil plants in 71 genera, 40 families and 28 orders. It is overlain by marine lower Eocene which is in turn overlain by the transgressing formations of the Wilcox group. The Wilcox flora is an unusually large one with about 550 described species in 182 genera, 83 families and 43 orders. There are 28 genera in the Ripley which are unknown in the Wilcox and if the latter flora is compared with earlier Upper Cretaceous floras of the same region about 40% of the genera known in these earlier floras are extinct before the Eocene.

There are 84 genera represented in this lower Eocene Wilcox flora which have never been found in any Upper Cretaceous flora in this or any other region and the vast majority of these are dicotyledons, and the species are all different.

It would seem that this brief résumé without greater detail justifies the statement that the dawn of the Eocene marks a great modernization of terrestrial floras, and that these floras show quite as marked a contrast when compared with Upper Cretaceous as do the terrestrial vertebrates or the marine invertebrates.

A well documented volume could be written on this subject but sufficient has been said to illustrate my point of view for the purpose of the discussion.

7. Prof. W. Gothan, Berlin.

Die Bedeutung der Paläobotanik als vollwertiges stratigraphisches Hilfsmittel.

Auf dem Internationalen Botanischen Kongress in Cambridge—England, 1930, habe ich über dieses Thema im allgemeinen gesprochen; der Vortrag ist in der Palaeontologischen Zeitschrift (13, 1931, S. 298) veröffentlicht worden. Der Aufförderung des Präsidenten der Botanischen Sektion des 'Indian Science Congress', zu der Tagung anlässlich des 25. Jubiläums eine diese Frage kurz beleuchtende Mitteilung beizusteueren, leiste ich hiermit Folge. Insbesondere erfülle ich hiermit einen Wunsch von Prof. Sahni, wenn ich den Wert der fossilen Pflanzen als Leitfossilien auch im Verhältnis zu den Angaben der Paläozoologie und Stratigraphie ins rechte Licht rücke und einzelne mir bekannte Fälle aufzeige, bei denen die Paläozoologen oder Stratigraphen und die Paläobotaniker verschiedener Meinung waren, die Paläobotaniker aber Recht behielten, indem sie sich *folgerichtig* auf die von den fossilen Pflanzen gebotenen Daten stützten. Man findet bis heutzutage die Anschauung, dass die auf Grund der fossilen Flora gemachten stratigraphischen Angaben unsicher seien und dass man sich auf sie nicht unbedingt verlassen könne, insbesondere, dass sie gegenüber denen der fossilen Fauna zurückzutreten

hätten. Insbesondere, wenn von Seiten der Paläobotaniker *und* Paläozoologen über dieselbe Schichtenfolge Aussagen vorlägen, verdienten die der Paläozoologen den Vorzug. Das ist nur insofern begründet, als die Mehrzahl der Fossilien überhaupt tierischer Natur ist und daher die Gliederung der geologischen Formationen sich im allgemeinen auf die fossile Fauna stützen *muss*. Richtig ist weiter, dass eine Erkennung so gering mächtiger Horizonte, wie sie z.B. auf Grund der Ammoniten im Jura ausgebaut worden sind, auf Grund der Pflanzen-fossilien in pflanzenführenden Ablagerungen nicht möglich ist. Denn es handelt sich bei diesen fast immer um terrestrische Ablagerungen, die in gleichen Zeiträumen in grösserer Mächtigkeit abgelagert werden als gleichaltrige marine Schichten. Es gibt jedoch viele Fälle, wo gar keine Fauna—oder keine horizontbestimmende—vorhanden ist, und dann müssen die etwa vorhandenen Pflanzen allein den Ausschlag geben. Selten kann man auch ganz bestimmte, wenig mächtige Schichtenfolgen an einer einzelnen Pflanze erkennen. Dies ist nur in begrenzten Gebieten möglich wo hin und wieder ein derartig beschränktes Vorkommen von Arten konstatiert worden ist, wie z.B. das der *Neuropteris Bogdanoviczi* in der höchsten Randgruppe Oberschlesiens (vergl. *Gothan*, Ob. Schls. Steinkohlenflora I, 1913, S. 211 und *Gropp*, Arb. Inst. Pal., *3*, i, S. 56). Richtig ist nun allerdings, dass die Paläobotaniker manchmal selbst durch Angaben auf Grund ungenauer Kenntnisse der Einzelheiten des Vorkommens der Arten in den betreffenden Regionen vorläufige und dann sich oft als unrichtig ergebende Angaben gemacht haben. Das sind aber Fehler, die mit dem Grundsätzlichen der Sache nichts zu tun haben.

Gehen wir jetzt zu einigen Beispielen über, die die Richtigkeit paläobotanisch—stratigraphischer Angaben zeigen. Wir können hier gleich bei dem genannten Oberschlesischen Steinkohlenbecken bleiben, das, nachdem *Gothan* das dortige Karbon 1913 paläobotanisch neu gegliedert hatte, bis in die neueste Zeit fortgesetzt Gegenstand sowohl paläobotanischer als paläozoologischer Studien gewesen ist. In unsern Beispiel handelt es sich speziell um die Stellung der obersten Randgruppe, der Schichten unter den mächtigen Sattelflözen, wo sich die jüngsten marinen Schichten des Beckens befinden (Porubäer Stufe der Ostrauer Geologen). *Klebelsberg* hatte im Jahre 1912 auf Grund seiner Untersuchung der marinen Fauna die Randgruppe im allgemeinen mit der Magerkohle des Ruhrreviers verglichen. Auch noch später finden wir bei den Kennern der Goniatiten, die ja ähnlich den Ammoniten im Jura in der Karbonstratigraphie eine besondere Rolle spielen, die Ansicht, dass die obere Randgruppe wegen des Auftretens des '*Gastrioceras circumnodosum*' mit dem Finefrauhorizont des Ruhrreviers zu vergleichen sei. Da auf dem ersten Heerlener Kongress 1927 zwischen den Paläobotanikern and Paläozoologen gar keine Einigung möglich war, indem die ersten für tiefes Namur die andern für unteres Westfal A waren, wurde die Diskussion damals aufgehoben. Bei den späteren Untersuchungen hat sich aber herausgestellt, dass die Bestimmung jedes Goniatiten auf Grund einer alten Abbildung falsch war ; die Paläobotaniker haben vollständig Recht behalten, was jetzt von allen Fachgenossen einhellig zugegeben wird. Bei dieser Gelegenheit kann man noch einmal bemerken, was ich früher schon gesagt habe, dass die Schichtenbestimmung auf Grund von paläozoologischen *und* paläobotanischen Befunden *zusammen*, wenn die Verhältnisse selber es zulassen, erfolgen sollte, dass aber bei beiden Forschungswegen dasselbe heraus kommen müsse. Eine Gleichung kann oft auf verschiedenem Wege gelöst werden, das Resultat muss aber das gleiche sein, oder die eine Rechnung ist falsch, und man muss den Fehler suchen.

Ein zweites sehr lehrreiches Beispiel bildet die Beteiligung der Paläobotanik an der Stratigraphie des Harzes und seiner Fortsetzungen, sowie von Teilen des Rheinischen Schiefergebirges, des Kellerwaldes usw. Auf die lange Geschichte der Entwicklung der Harzstratigraphie, an der zahlreiche Forscher von höhem Rang beteiligt sind, kann hier nicht

eingegangen werden, sondern es können nur hier besonders interessierende Punkte herausgehoben werden. Da ist zunächst die sogenannte Tanner Grauwacke des Oberharzes, die nach vielem Hin und Her von den im Anfang des Jahrhunderts massgebenden Geologen wie *Lossen*, *Denckmann*, *Kayser*, *Koch* und *Beushausen* als silurisch angesehen und schliesslich auch von *H. Potonié* in seiner Flora des Silurs und Kulms ' 1901 als silurisch aufgeführt wurde. Er hatte sie ursprünglich und zwar richtig als oberdevonisch angesprochen, was bei ihr als einer echten Cyclostigmen-Flora durchaus richtig war, hatte sich aber von den genannten Geologen überstimmen und uberzeugen lassen. Später hat er allerdings diese Ansicht wieder zurückgenommen. Durch die neueren Untersuchungen des Harzes besonders von *Schriel* und *Dahlgrün*, mit denen ich die Sache sehr oft besprochen hatte, ist die Sachlage vollständig geändert worden. Das kommt sowohl in dem 'Harzführer' von *Schriel* und *Dahlgrün* (I. Teil, 1925, S. 135) als auch in den Erläuterungen der neuen geologischen Blätter zum Ausdruck, soweit sie schon erschienen sind. In dem genannten 'Führer' erscheint die 'Tanner Grauwacke' noch als Unterkarbon. Die Autoren sind dann aber nach dem Erscheinen des Führer vom oberdevonischen Alter dieser Schichten uberzeugt worden, wie sich aus den Erläuterungen ergibt. Für den Paläobotaniker musste dies bei dem Vorhandensein der Cyclostigmen von vornherein feststehen, wie auch *Nathorst* bald nach Erscheinen der *Potonié*-schen 'Silur-und Kulm Flora' bemerkt hat. In den Erläuterungen z.B. zu Bl. Zorge (Lief. 282, 1 S. 17 ff.) ist die Tanner Grauwacke als Oberdevon aufgenommen.

Die erste Bresche in das 'Silur' der älteren Harzgeologen wurde übrigens nicht im Harz selbst gelegt, sondern bei der Veröffentlichung des geologischen Blattes Schönebeck mit den Quarziten von Gommern im Jahre 1924 (s. Erläuterungen Bl. Schönebeck, S. 11). Dieser Quarzit, der von Denckmann durchaus richtig mit dem Acker-Bruchberg Quarzit des Harzes und dem Kellerwald-Quarzit in Verbindung gebracht wurde, galt wie die anderngenannten Schichten und wie sich auch aus *H. Potonié's* 'Silur-und Kulm-Flora' ergibt, ebenfalls als silurisch. Auf eine Anfrage des früheren Präsidenten der Preussischen Geologischen Landesanstalt *Beyschlag* über die Meinung der Paläobotanik vom Alter der Gommerner Quarzite, musste ich die Antwort erteilen, dass diese nur als unterkarbonisch betrachtet werden könnten, und zwar wegen des Vorkommens verschiedener Archaeopteridenblätter und von zweifellosen Stigmaria-resten. Daraufhin wurde auf der geologischen Karte der Quarzit geger die Meinung verschiedener anderer Geologen als unterkarbonisch gekennzeichnet. Damit war aber zugleich die Frage aufgerollt, wie es nun mit dem Acker-Bruchberg und Ilsenburger Quarzit im Harz selbst und mit dem genannten Kellerwald-Quarzit bei Wildungen sei, die ebenfalls als silurisch galten. Da vom Acker-Bruchberg ebenfalls eindeutige Stigmariareste vorliegen, so war für den Paläobotaniker die Antwort von vornherein gegeben, was ja auch bei der bereits erkannten Gleichaltrigkeit mit dem Gommerner Quarzit folgerichtig war, nämlich dass auch dieser unterkarbonisch sei. Im dem bereits genannten 'Führer' (I. S. 124) ist die Frage noch offen gelassen und die Meinung ausgesprochen, dass sich Gesteine verschiedenen Alters in den Quarziten des Acker-Bruchbergs befinden könnten. Auf der geologischen Ubersichtskarte des Harzes (1 : 200,000) sind die Schichten als 'oberdevonisch' bezeichnet. Nach dem paläobotanischen Befund, sind sie wenigstens z.T. als unterkarbonisch wie der Gommerner Quarzit anzusehen. In den sicher gleichaltrigen Kellerwald-Quarziten hat dann später *H. Schmidt*-Göttingen eine *unterkarbonische* Fauna nachgewiesen, wodurch die Frage im Sinne der Paläobotaniker erledigt ist.

Nur wer weiss, was für Kämpfe die Harzgeologie im Laufe der Zeit gekostet hat und wie z.B. auch ich mich mit den Harzgeologen herumstreiten musste, die ursprünglich nicht zu überzeugen waren, kann die Schwierigkeit der Stellung eines Paläobotanikers besonders gegenüber der früheren 'Silurfront' angesehener Geologen verstehen. Die Beteiligung

der Paläobotanik hierbei ist in der Literatur relativ wenig in die Erscheinung getreten (vergl. u.a. *Schriel-Gothan,* Jb. Preuss. Geologische Landesanstalt, *48*, S. 302 ff), und deswegen ist vielleicht diese kurze historische Darstellung von besonderm Interesse.

Weitere Beispiele in dieser Frage bieten das Ruhrrevier und seine nördlichen Anhängsel, (Ibbenbüren und Piesberg) sowie seine westlichen Fortsetzungen, das Erkelenzer und Aachener Karbon. Das Ruhrrevier ist ein klassisches Beispiel für die Gültigkeit der Hilt-schen Regel, die auch im wesentlichen auf Grund der dortigen Verhältnisse aufgestellt worden ist. Sie besagt, dass normaler Weise in Steinkohlenablagerungen der Gasgehalt, d.h. der Gehalt an flüchtigen Bestandteilen der Kohlenflöze, von oben nach unten allmählich abnimmt. In keinem andern Becken kann mit solcher Regelmässigkeit eine Abnahme des Gasgehalts der Kohlen von oben nach unten nachgewiesen werden, von Kohlen mit 40% Gas bis zu Halbanthraziten mit 10% Gas und noch weniger in den Kohlenspuren des Flözleeren. Daraus ergab sich für die Geologen eine ebenso bequeme wie billige Methode die Schichten im Ruhrbecken oder dessen nördlicher Fortsetzung, in dem Münsterschen Kreidebecken, in Bohrungen zu horizontieren, indem einfach der Gasgehalt der Flöze festgestellt wurde und darnach die Horizonte, die ja im Ruhrrevier sogar nach der Kohlenart benannt werden, sodass hier eine blosse Kohlenqualitätsbezeichnung zu einem stratigraphischen Begriff geworden ist. Bei den Versuchen jedoch, dieselbe Methode in den losgelösten Anhängseln des Ruhrbeckens, namentlich bei Ibbenbüren und dem Piesberg sowie auch beim Erkelenzer Karbon anzuwenden, ergaben sich vollkommene Fehlschlüsse. Die mageren Kohlen von Ibbenbüren und die Anthrazite des Piesbergs galten bei den älteren Geologen als womöglich noch älter als die Magerkohlen des Ruhrbezirks. Die Paläobotanik ist es gewesen, die mit diesen Irrtümern aufgeräumt hat; Cremer hat schon (Glückauf 1895, S. 129) die Sachlage richtig erkannt. Der richtige Anschluss der jetzt isolierten karbonischen Horste oder Aufpressungen von Piesberg-Ibbenbüren ist erst von *Haack* und *Gothan* viel später nachgewiesen worden (Glückauf 1924, No. 26).

Der sogenannte Horst von Mühl-Wassenberg im Erkelenzer Karbon war ebenfalls auf Grund der Magerkeit der Kohlen viel zu tief im Schichtenverband angesetzt worden (*Krusch* und *Wunstorf,* Glückauf 1907, No. 15). Die Paläobotaniker (*Jongmans, Gothan*) haben die Irrtümlichkeit dieser Auffassungen auf Grund der Flora nachgewiesen. Übrigens vertraten für das Aachener Karbon manche Bergleute noch ziemlich spät die Anschauung, dass die mageren Kohlen des Engfaltungsbezirks im Wurmbecken der tieferen Magerkohle des Ruhrbeckens entsprächen. Hier hat ebenfalls die Flora (zusammen mit andern Umständen) den richtigen Weg gewiesen.

Wie primitiv manchmal die Auffassung mancher Geologen im Anfang des Jahrhunderts über die stratigraphischen Möglichkeiten der fossilen Flora war, sei an einem Beispiel einer jurassischen Kohle aus China gezeigt, das ich selbst erlebt habe. Aus dem Kohlenvorkommen von Pingshiang (verg. z.B. *Sze,* Mem. Nat. Res. Inst. Geology, XII, 1931, Nanking) erhielten wir um das Jahr 1904 durch den Ingenieur *Lutz* eine Sendung von Pflanzen und Tierfossilien. Unter den letzten befanden sich auch Süss-oder Brackwasserzweichaler vom Habitus der *Carbonicola*-Arten, deren allgemeiner Charakter sich ja in den postkarbonischen Formationen, auch im Jura, Wealden (Cyrenen) nicht gerade erheblich verändert hat. Das kohlige Aussehen dieser Muscheln und die Ähnlichkeit mit den *Carbonicola*-Arten des Karbons brachte einige hiesige Geologen auf die Idee, es handle sich um karbonische Kohlen, und ich entsinne mich noch sehr genau, wie *H. Potonié* und ich damals Mühe hatten, die betreffenden Herren zu uberzeugen, dass das Vorkommen von *Dictyophyllum,* von grossblättrigen *Cladophlebis*—Arten wichtiger sei, als die nichts oder wenig besagenden 'Anthracosien' wie diese Muscheln damals meist genannt wurden. Dabei kam aber vielleicht bei den Geologen dazu, dass sie die Kohlen gern als karbonisch abgestempelt hatten, weil sie meinten,

dass damit über die bessere Qualität etwas ausgesagt sei. Ähnlich war es mit gewissen Jurakohlen von Schantung, deren jurassisches Alter gewissermassen verheimlicht wurde. Dass aber Jurakohlen und auch tertiäre Kohlen so gut sein können wie karbonische, ist ja jetzt wohl allgemein bekannt.

Ein weiteres Beispiel für unsere Frage bietet die Geschichte der Stratigraphie des grossen Kohlenbeckens von Kuznezk am Altai. Während wenigstens für den oberen und wichtigsten Schichtenteil der paläeozoischen Kuznezker Kohlenformation besonders auf Grund des Vorkommens von Callipteriden die Paläobotaniker sich für permisches Alter aussprechen mussten, konnten sich die Paläozoologen mit diesem Standpunkt nicht befreunden und setzten die Schichten tiefer ins Karbon auf Grund der Fauna. Es ist mir nicht bekannt, wie sich augenblicklich die Paläozoologen dazu einstellen. Die Frage dürfte nunmehr endgültig zu Gunsten der Paläobotanik entschieden sein durch den Vergleich mit dem von *Bexell* festgestellten Profilen in Nanschan-Gebiet (Prov. Kansu, nordöstliches Tibet). Hier wurde nach der vorläufigen Veröffentlichung von *Bexell* und *Halle* festgestellt, dass die Schichten mit Angaraflora (Kuznezker Flora) und zahlreichen Callipteriden über Schichten mit typischer *Gigantopteris* flora, wie sie im östlichen Asien bekannt ist, lagern. Diese ist von *Halle* schon früher und ganz sicher mit Recht als permisch beurteilt worden, was noch später und jetzt vor kurzem durch *Callipteris*-Funde in Schansi bestätigt wurde. Danach dürften die Shihhotze-Schichten des Profils von Schansi dem unteren Perm (Rotliegenden) angehören; die betreffenden Angaraschichten von Nanschan können aber unmöglich als karbonisch gelten, sondern müssen jüngeren Schichten des Perm angehören und demgemäss die betreffenden Schichtenpakete von Kuznezk auch (Zone II von *Neuburg*).

So darf man auch dem Ergebnis der Untersuchung der Spiti-Pflanzen aus den Po-Schichten des Himalaya, die *Gothan* und *Sahni* als unterkarbonisch bestimmten, durchaus Glauben schenken, zumal eigentliche Gegengründe paläozoologischer Art nicht vorliegen. Ein mittelkarbonisches Alter, d.h. also etwa Westfal im Sinne der Heerlener Beschlüsse, wie es bisher mit Vorliebe angenommen wurde, ist abzulehen.

Dafür, dass auch im Mesozoikum manchmal unter entsprechenden Umständen Florenfolgen an den verschiedensten Stellen der Erde sich stratigraphisch sehr brauchbar zeigen, kann die Gleichartigkeit der Folge der Rhät-und Liasflora in Schonen und Ostgrönland genannt werden; hier sind besonders die Arbeiten von *Harris* zu nennen. Hier wie dort lässt sich übereinander unschwer eine rhätische und unterliassische Stufe unterscheiden, die tiefere unter anderm durch *Lepidopteris Ottonis* charakterisiert. *Harris* unterscheidet eine rhätische *Lepidopteris*- und eine liassische *Thaumatoperis*-Stufe, die sich in ganz ähnlicher Weise in Schonen wiederfinden. 1914 wurden von Gothan in Franken die betreffenden Schichten ganz ähnlich gefunden und unterschieden und daraufhin die sogenannte 'Rhätflora' von Franken als liassich bezeichnet und ferner die *Lepidopteris*-Schichten von Koburg und Oberschlesien als rhätisch angesprochen. Weitere Charakerpflanzen mögen in den Arbeiten von *Nathorst*, *Harris* und *Gothan* nachgelesen werden (*Nathorst*, Floran vid Bjuf. Sver. Geol. Undersökn. C, No. 27, 33, 85, 1878–86; *Gothan* Abh. Nat. Ges. Nürnberg, 19, 1914; *Harris*, Rhaetic Floras, Biolog. Reviews, 6, No. 2, s. 133, 1931; *Gothan*, Ztschr. D. Geol. Ges. 87, 1935, No. 10).

Auch im Tertiär Mitteldeutschlands spielt die Paläobotanik mehr und mehr eine ausschlaggebende Rolle, da vielfach andere genügende Indices fehlen. Als Beispiel sei hier die Dürener Braunkohle genannt (Rheinl.). Schon vor mehr als 10 Jahren habe ich mit *Wunstorf* eine Gleichaltrigkeit mit der Ville-Kohle erkannt und versucht, unsere Meinung für die geolgische Kartierung durchzudrücken. Dies gelang uns aber damals nicht; erst jetzt ist in Folge der Untersuchungen von anderer Seite die richtige Erkenntnis zum Durchbruch gekommen und die 'Kieseloolith-Schichten', auf Grund deren u.a. die betreffenden Kohlen

als Pliozän angesprochen worden, haben jetzt zum Teil ihre Bedeutung eingebüsst, und die Paläeobotanik ist in ihr stratigraphisches Recht getreten. Man könnte noch mehr über ihre Rolle in der Einordnung der Braunkohlen des Mitteldeutschen Tertiärs sagen. Es mag aber dabei sein Bewenden haben, da der Zweck unserer Darlegungen, die *Wichtigkeit und Richtigkeit der Aussagen der fossilen Flora in stratigraphischen Hinsicht auch gegenüber etwa anderslautenden paläozoologischen darzutun*, erreicht ist.

8. Dr. Alex. L. du Toit, Johannesburg.

Homotaxis and continental drift.

The apparent discrepancies in the dating of formations by means of their respective marine and terrestrial fossils can be ascribed to :—

(1) Uncertainties pertaining to the geological system-boundaries either locally or regionally, whereby correlation-errors are introduced, e.g. the limit between Carboniferous and Permian.

(2) Inaccuracies in fossil identifications, the more frequent in the case of fragmentary plant remains.

(3) Presence of persistent forms or 'hold-overs'.

(4) Divergences in the evolutionary trends in sea and on land.

(5) Evolutionary changes during migration along extended paths, whereby, as forcefully pointed out by Huxley in 1862, widely parted faunas could become 'homotaxial' instead of synchronous, correspondences in stratal successions not necessarily implying contemporaneity in deposition. Considering the enormous extent of the earth's surface, absolute synchronism throughout geological history would seem distinctly improbable.

(6) Convergences in faunal or floral types, due basically to similarities in their particular environments. For example, the likeness between the Permian floras of Angaraland and Gondwanaland, which were both temperate or cold climate assemblages, contrast with those of the rest of the world, which generally had a warm habitat.

(7) Climatic, oceanographic, orogenic or other influences that have affected in different degrees or senses the life of the seas and lands and impressed themselves differently on the marine and terrestrial biota. Such changes are currently presumed to have been more marked or uneven upon the lands, where the life was subject to extreme variations n temperature, humidity, etc.

(8) A further and vital factor, which has not received attention so far, is, however, *Continental Drift.* The author has elsewhere set forth the numerous arguments favouring a creeping of the condensed land-masses of 'Laurasia' and 'Gondwana' over a revolving core, on the whole southwards during the Devonian and Carboniferous, when the motion became reversed, with some anti-clockwise rotation as well. Such resulted in the progressive shift across the face of the Earth of the main climatic zones, with consequent changes of biological environment and therefore of evolutionary influences, especially upon the lands and particularly in regard to their vegetation, which had not the mobility of the animals.

As an extreme case an area could well within an epoch have changed from say a sub-tropical through a dry to a wet-temperate environment, whereas in an adjoining one the reverse might have occurred. The coals of the Palæozoic were accumulated under either warm-moist or cold-moist conditions, and respectively mark out the former equatorial or polar sides of the two high-pressure low-rainfall girdles, which in turn tend to be characterized by continental 'red beds' phases. The frequent association of such red strata with the coal-bearing facies finds its explanation in fluctuation or migration of the northern and southern limits of those low-rainfall girdles.

The progress of such a climatic 'wave' should tend obviously to speed up, or contrariwise to retard, the normal evolutionary processes and thereby lead to the abrupt appearance of new forms and/or to the preservation of old ones, as well instanced in the Triassic flora of South Africa.

(9) Discordances in the datings derived from the marine and terrestrial remains are hence likely, though the maximum lack in agreement may perhaps nowhere have exceeded a fraction of an epoch—say a few million years or so.

(10) Although the marine fossils would generally constitute a fairly consistent geological clock, palæobotanists should have no hesitation in stressing the plant evidence should the latter be weighty, although at variance with the conclusions currently drawn from the associated marine faunas. Thus for certain strata commonly recorded as Lower Permian from their fauna, their flora is wholly indicative of a late Carboniferous age, such apparent discrepancy being largely due to the upper limit of the Carboniferous having consistently been drawn at a lower level than is done by the Russian geologists for the type region of the Permian.

9. PROF. H. C. SZE, Nanking.

Die Meinungsverschiedenheit zwischen Palaeozoologen und Palaeobotaniker ueber die Altersfrage.

Die Meinungsverschiedenheit zwischen Palaezoologen und Palaeobotaniker über die Altersfrage ist bei uns genau dasselbe. So z.B. über das Alter der *Gigantopteris*-Flora ist die Meinung zwischen Geologen immer noch nicht einig und wird vielleicht niemals einige sein. Halle, White, Gothan und Sze hielten es für Unterperm ; T. K. Huang hat aber auf Grund der Fauna und stratigraphischen Verhältnisse in Südwest-China es bereits zum 'Upper Permian' umzudeuten versucht. Die Japanische autoren (Yabe u. a.) haben immer noch schlechtweg die *Gigantopteris*-Flora als Permo-Trias betrachtet. In einer neuen Veröffentlichung, stellen Ting und Grabau die Shihhotze Serie in Shansi zum 'Middle Permian' (Report of XVI Intern. Geol. Congr. 1933). Man muss also darüber noch mehr Arbeiten um diese Frage klar zu machen.

10. MR. H. CROOKSHANK, Calcutta.

The Ammonites of the Madras East Coast and the Age of the Upper Gondwanas.

Dr. L. F. Spath's description of Upper Neocomian ammonites in the Gondwana rocks of the East coast of Madras is of the utmost importance to Indian geology. If his somewhat tentative identifications are accepted it raises the age of these rocks by a whole geological division.

One point about which he seems to be misinformed is that this determination will raise the age of the Rajmahal plant beds throughout India. The rocks in which the fossil ammonites have been found are the Ragavapuram shales, the Sripermatur group, the Budavada sandstone and the Vamevaram shales. Spath reports that the fauna of all these rocks is identical. Feistmantel (*Pal. Ind. Sr. II, IX and XII, I, pt. 4, 191–224*) already regarded their floras as indistinguishable one from another. He describes them as being midway between the Rajmahal flora and the Jabbalpur one. The only true Rajmahal floras from the East Coast of India occur in the Golapilly beds and the Athgarh sandstones. King (*Mem., XVI*) expressly states that the Golapilly beds underlie the Ragavapuram shales with their ammonite fauna. He could not be

certain that they were separated by an unconformity, but he believed they were.

Spath's identification raises the age of the plant beds in the East Coast Gondwanas from middle Jurassic to lower Cretaceous (? Barremian). Arguing from the floras found in Kota and Jabbalpur he concluded that these beds as well as the somewhat older Rajmahals should be raised from lower and middle Jurassic to lower Cretaceous also. I propose to show that the correctness of this deduction is very questionable.

The modern tendency in palæobotany is to greatly reduce the number of species based on leaf impressions alone. Thus the following plants regarded as distinct by Feistmantel are regarded as varieties of the same species by Seward:—

Ptilophyllum acutifolium,
Ptilophyllum cutchense,
Otozamites hislopi,
Otozamites gracilis,
Otozamites angustatum,
and *Otozamites distans*.

Any of these would now be described as *Ptilophyllum acutifolium*. This wholesale rejection of species has tended to greatly reduce the differences between the various Indian Upper Gondwana floras.

Work in the Satpura Gondwana basin (*Crookshank, Mem. LXVI, pt. 2*) has recently brought to light 12 new Jabbalpur species. Nine of these were formerly regarded as typical of the Rajmahal flora, and two of the Umia.

In spite of these discoveries the Rajmahal flora still remains fairly distinct on account of the abundance of large cycadaceous fronds in it, and of the presence of such ancient forms as *Danæopsis* and *Thinnfeldia*.

The remaining Upper Gondwana floras are brought much closer to one another than heretofore, so that it is doubtful if the distinctions between them have more than a local significance due to their wide geographical distribution. If anything the flora of Umia seems to be younger than those of Jabbalpur, Kota, and the upper Gondwana beds of the East Coast of Madras, for it is deficient in the more ancient plant genera such as *Dictyozamites*, *Pterophyllum*, *Nilssonia*, and *Tæniopteris*. Spath's statement that 'plant-beds comparable to those formed in Kachh in Portlandian times (Zamia shales of Nurrha) and in the upper Tithonian and lowest Neocomian do not seem to be known from Peninsular India' seems designed to explain the reason why there is such a very large difference in age between the upper Gondwana beds of Kachh and those of the Madras East Coast. The statement does not, however, bear investigation. The *Zamia* of the Nurrha shales is a variety of *Ptilophyllum acutifolium*. This leaf impression is certainly the commonest of all those found in the upper Gondwana rocks of Peninsular India. It is often found in great profusion among the carbonaceous shales of the Jabbalpur series, and in some cases it is the only leaf impression present.

As far as the fossil floras are concerned there is little difference between those of Kachh, Jabbalpur, Kota, and the Madras East Coast. The ammonites in Kachh show that the Umia flora is upper Jurassic, those identified from the Madras East Coast that the flora there is lower Cretaceous. The only reasonable deduction is that the land flora in India changed very little over a prolonged period in the upper Jurassic and the lower Cretaceous. Such a conclusion would not be particularly remarkable, for similar floras persisted with little change from lower Jurassic to the end of the Wealden in Europe and other areas. It seems to me quite unfair to say that the Jabbalpur and Kota floras are Cretaceous because those on the East Coast of Madras are. They might equally easily be Jurassic, as is the Kachh flora.

But there is other evidence which tends to show that the Jabbalpurs and Kotas are at least as old as the Kachh plant beds, and perhaps older,

Evidence from fossil leaf impressions is never very satisfactory, but such as it is it tends to place the Jabbalpurs and Kotas in the lower half of the Jurassic. All the Jabbalpur species range through wide periods in the Mesozoic era, but, as one genus, *Dictyozamites*, is especially characteristic of the mid-Jurassic, and as others, notably *Pterophyllum*, *Nilssonia*, and *Tæniopteris*, are rarely found higher than this, it is probable that the Jabbalpur rocks are at least as old as mid-Jurassic. As the Kachh plants seem to be slightly younger than the Jabbalpur ones, and as there is often an apparent difference in age between marine and terrestrial forms this position would be quite in accordance with the ammonite evidence from Kachh.

In support of the evidence from the fossil floras there is field evidence from at least three areas to show that the Jabalpur and Kota beds overlie quite conformably beds in which Triassic and Rhætic Reptilia and Amphibia are found, and from another area which shows that fresh water fish remains of Liassic age occur in beds either immediately below or interbedded with the plant remains.

The Kota-Maleri area is by far the most important of these. Some of the best known geologists of the Geological Survey of India have visited or mapped the rocks of this area. They all agree that there is only one rock formation present. At its base it is rich in coloured clays and poor in sandstones. As one passes upwards through the succession the clays become rarer and the sandstones commoner till at the top of the formation it is mainly sandstone. About the middle of this formation occur three limestone bands.

The plant beds with Jabalpur fossils are commonest at the top of the formation, but they extend down as far as the limestone bands. Opinions are divided as to whether they are interbedded with them or not.

The limestone bands contain a rich fish fauna of liassic affinity (*Egerton and Miall. Pal. Ind. Ser. IV, Vol. I*). Reptilian and Amphibian remains are found most abundantly at the base of the formation, but they extend upwards as far as the limestone bands and are locally interbedded with them. All are agreed on this point. The age of the reptilians has been determined as uppermost Trias or Rhætic. I wish to emphasize here that several of the most famous of Indian Geologists (*Lydekker, Pal. Ind. Ser. IV, Vol. I; King, Hughes, Blanford*) have failed to find any signs of a break in sedimentation in this formation, nor is the succession of plant and animal forms any reason for suspecting the presence of one.

In the Jabbalpurs of the Satpura Gondwana basin there is a large fossil flora. The Jabbalpurs pass downwards without any sign of unconformity into the Denwas a formation built up of thick beds of red clay and white sandstone. In the red clays some hundreds of feet below the plant beds remains of *Mastodonsaurus*, a late triassic reptilian, have been found.

The situation at Tiki where a fauna almost identical to the Maleri one has been discovered, is very similar. The connection of the Tiki beds with the overlying Jabbalpurs is, however, not so clear as it is in the Satpuras, and at Maleri.

Thus the field evidence strongly favours the view that the Jabbalpurs and Kotas are closely connected with the underlying bone beds. If it is desired to move the Jabbalpurs bodily up to a lower Cretaceous horizon, it becomes almost necessary to move the Maleris and Denwas up to the top of the Jurassic or the base of the Cretaceous. To move the age of reptilians, amphibians, and fishes upwards by a whole geological epoch seems to me to be a ruthless act.

Having regard to the field and fossil evidence it would be much wiser to leave the base of the Jabbalpur series in its present mid-Jurassic position, that is a little older than the plant beds of Umia with their interbedded ammonites of Portlandian age. To correlate the base of the Jabbalpur with the equally distant plant beds of the Madras East Coast seems to me quite unnecessary.

The period during which Jabbalpur sedimentation continued is quite uncertain. The beds are strung out in a long line from Rewa to western Hoshangabad, a distance of several hundred miles. They are not quite continuous but sufficiently nearly so to be sure that they have been deposited in two or three basins lying along the southern margin of the present Narbada valley. The characteristic and extremely uniform lithology of the group suggests that the conditions of deposition were everywhere the same. There is no evidence, however, that the different basins are of exactly the same age. There is in fact a little plant evidence to show that they were not. Thus at Jabbalpur the fossil plants are mainly conifers and ferns of relatively modern appearance, while in the Narsinghpur district (*Crookshank, Mem. LXVI, Pt. 2*), some 50 miles further west, large cycadaceous fronds of archaic aspect abound. Although the Jabbalpur rocks are never very thick, it may be that they have been slowly deposited over a long period of time during which land conditions remained very stable. They may even represent the period from mid-Jurassic to mid-Cretaceous. That they could not have continued much later is fairly certain, for the next flora found in Peninsular India, that associated with the earliest flows of the Deccan Trap, is entirely different. This flora is considered to be earliest Eocene. As the palms are represented in it by numerous species it is certain that its roots must extend far down into the Cretaceous. There is, however, not a trace of a palm in any of the upper Gondwana rocks.

The occurrence in Madras of lower Cretaceous ammonites in beds containing a flora characteristic of the lower or middle Jurassic is somewhat of a mystery. It is a well-known fact that mesozoic floras cover an enormous time range. From the earliest Jurassic to the end of the Wealden period there is no very marked change. It is quite possible that a Jurassic flora could have lingered along the Madras coast well into the Neocomian period, but it is remarkable that such relatively ancient genera as *Dictyozamites*, *Pterophyllum*, *Nilssonia*, and *Tæniopteris* should be so well represented there; so strange is this that it must inevitably cast doubt on Spath's conclusion, the more so as this is based almost entirely on generic rather than specific determinations, and the material available was badly preserved.

Fortunately there is some chance of checking the ammonite evidence. Associated with these fossils is a large marine fauna, mainly lamellibranch. So far as I can ascertain, these have never been thoroughly investigated. Two marine fossils from the Tripetty beds immediately overlying the ammonites in the Godaveri delta were identified by Stoliczka as *Trigonia ventricosa* and *Trigonia smeei*; forms which are extremely common in the Umia (Portlandian to early Necomian) of Kachh (*King, Mem. XVI*). This directly contradicts the evidence of the ammonites, and suggests a Jurassic age for the plant beds here as elsewhere.

11. Dr. R. W. Chaney, Berkeley (California).

Many discrepancies in the stratigraphic testimony offered by terrestrial plants and animals appear to result from factors involved in geographic distribution. This is particularly true in the case of Cenozoic rocks, whose stratigraphic units are finely differentiated, and in which the details of faunal and floral development are relatively well known. An example may be mentioned which was involved in a recent study in western North America.

In the Ogallala formation, laid down during later Tertiary time on the eastern flanks of the Rocky Mountains, a mammalian fauna including horses and a beaver has been referred to the Lower Pliocene. At this same locality in north-eastern Oklahoma, there has been collected a flora made up of well-preserved leaves of angiosperms. All its genera and more than half the species have been previously recorded in the Miocene of Colorado and Oregon. If it be assumed that during the

Upper Miocene the vegetation was uniform from Oregon to Oklahoma, there can be no conclusion other than that the evidence of the plants is not consistent with that of the animals.

Well-marked differences may be observed between the modern vegetation of Oregon and of Oklahoma. Our knowledge of the Tertiary history of western America gives us little basis for supposing that such differences were any less apparent during Miocene and Pliocene time. The attitude of the orthodox stratigrapher has served to obscure or completely prevent the recognition of local differences in plant life; but there can be no rational basis for the assumption of a 'cosmopolitan' flora over a range of nine degrees of latitude, and across a north-south range of mountains. The fact that a fossil flora in Oklahoma has genera and species in common with one in Oregon may in no accurate sense be interpreted as indicating that the deposits containing them are of the same age. In the case of land plants, which migrate relatively slowly, such a resemblance is probably an indication of a *difference* in age.

Studies in progress over the past two decades are yielding a large body of evidence in support of the theory that the more characteristic elements of Tertiary vegetation have migrated southward down both sides of the Pacific from a northern source. This migration is considered to reflect a trend towards a colder and drier climate, resulting from gradual emergence during the Tertiary, and no doubt from other causes. Plants which characterize the Miocene of Oregon are known to have been present in Alaska during the Eocene. It is reasonable to suppose that these same plants should have occupied a position still further south during the Pliocene, as a result of a continued response to climatic change. The presence in the Pliocene of Oklahoma of vegetational elements which characterize the Miocene a thousand miles to the north-west is therefore to be expected. Greater mobility of mammals appears to have made possible their rapid migration over wide areas during the Pliocene. A closer faunal uniformity may therefore be expected than is the case with plants. It is possible that with increased knowledge of their geographic and stratigraphic occurrence, the idea that animals were contemporaneous over extensive areas of sea or land may also have to be modified. In any case the abandonment of the concept of cosmopolitan floras in no way affects their value as stratigraphic indicators, if their latitudinal relations are considered and if their direction of migration is known.

A large number of apparent inconsistencies between the age evidence of plants and animals have resulted from inaccurate recording of their stratigraphic position. The question of the boundary between the Mesozoic and Cenozoic rocks in the Rocky Mountain area, long under dispute, appears to involve errors in establishing the vertical position of several of the floras involved, and doubtless of certain faunas as well. These errors are being corrected through the studies of Brown and Dorf. The age of the Auriferous Gravels on the western flanks of the Sierra Nevada was obscured by contradictory data until it became known that the floras range in age from Upper Eocene to Pleistocene. It seems clear that with adequate observation and critical analysis of their geographic and stratigraphic occurrence, Tertiary faunas and floras will provide chronological evidence in which no discrepancies appear. The very existence of such discrepancies as now appear is an indication of our inaccuracy of method or interpretation.

12. Dr. A. B. Walkom, Sydney.

On the whole there seems in Australia to be little conflict between the evidence of plant and animal fossils in regard to the age of the beds in which they occur. I think the greatest difficulties result from consideration of small portions only of a fauna or flora and the use of such small portions as indicators of age. I think there is often too little

appreciation of the presence of 'hold-overs' in any fauna or flora, and quite frequently these 'hold-overs' are singled out and stressed as age indicators—in reality they will always indicate an age greater than the actual age of the beds in which they occur.

This, I believe, may be the case with the Wankie beds in Rhodesia where the *Pecopteris* and *Sphenophyllum* may not outweigh the *Glossopteris* flora in the determination of age.

There has been, during recent years, some controversy as to the age of the beds formerly called 'Permo-Carboniferous' in Australia, and the age of the *Glossopteris* flora. A recently published excellent analysis of the fauna in these beds in New South Wales (by Raggatt and Fletcher, *Records Aust. Museum*, xx, No. 2, p. 165) strongly supports the opinion that the whole of the system is of Permian age, and therefore the first appearance of the *Glossopteris* flora in Australia would be some 1,500 feet above the base of the Permian.

According to Mr. F. Chapman of Melbourne the evidence from the Foraminifera in the New South Wales 'Permo-Carboniferous' is that they range through Carboniferous to Permian in only a few cases, but are otherwise typically Permian. As far as Australia is concerned, then, it seems now that the Permian faunas and flora are in accord and there is nothing to support a suggested Carboniferous age for any of the *Glossopteris* flora.

13. DR. EMILY DIX, London.

The Relative Values of Fossil Plants and Shells in correlating Coal Measure Rocks.

The evidences afforded by fossil plants and shells supplement one another and should always be taken into consideration, whether in the identification of a particular coal seam over a small area or in establishing sub-zones or zones in rocks of Coal Measure age. When considering the identification of a coal seam one should examine all the evidence available: the character of the seam, the lithological characters of the roof and the associated measures, and the fauna and flora found in the roof shales. In cases where doubt exists a spore-analysis of the seam in question should be made. Thus, an ideal classification of the Coal Measures should be based on the vertical distribution of species of non-marine and marine shells, arthropods, plants and to a certain extent on the lithological characters of the rocks themselves.

It is generally true that the evidence afforded by either the non-marine shells or the plants may be a reliable guide to the correct determination of a zone or smaller unit of Coal Measure strata. But in other cases, difficulties arise owing to the great variation in the characters of the strata especially at some horizons, and as a result all possible lines of evidence should be taken into consideration.

In some cases the non-marine and the marine shells make possible the most detailed correlation, yet at certain horizons the plants are so characteristic that they are quite as valuable for correlation as the non-marine shells. In areas, too, where shells are rare, or absent, or where the species found are of no diagnostic value, the evidence afforded by the plants cannot be neglected, and is of necessity the more important.

On the Continent, it has been recognized for many years by such well-known research workers as Profs. Gothan, Renier, Jongmans and Bertrand that the distribution of the plant impressions found in the roofs of coal seams are reliable, not only for classifying the Coal Measure strata, but also for identifying individual seams. As a result it is customary in these coalfields to use the plants rather than the shells for zonal purposes. However, it has been shown by Prof. Pruvost and other workers that the results based on the non-marine shells were not in discordance with the results obtained by a study of the plant impressions. In this country,

on the other hand, a great difference of opinion arose between the workers on the plants and the shells with regard to the classification and correlation of Coal Measure strata in the various coalfields, which has made several geologists in Great Britain very sceptical indeed concerning the utility of either the plants or shells for zoning these rocks. Some have even expressed the opinion that no great changes took place in the characters of the floras and faunas as one proceeds upwards through the Coal Measures. This is a fallacy which is easily exposed. In my opinion the changes exhibited by the faunas and floras of the Coal Measures can be compared with those shown by the goniatites and associated faunas of the Namurian or with the corals and associated faunas of the Avonian—faunas which are recognized as reliable indices for zoning the strata in which they are found.

Non-Marine Shells.

Let us first consider the value of the non-marine shells, namely, *Carbonicola, Anthracomya, Anthraconauta* and *Naiadites*, (freshwater or estuarine forms which lived in the lagoons and estuaries of Coal Measure times) for (1) identifying coal seams, and (2) zoning Coal Measure rocks.

(1) *The Value of Non-Marine Shells for identifying Coal Seams.*—Dr. Wheelton Hind demonstrated that these shells could be used in correlating the Coal Measures of North Staffordshire, and he also gave an account of their broad zonal distribution in other coalfields in Britain. Mr. J. T. Stobbs extended his results in 1906, and for many years he has used these fossils in the identification of coal seams throughout the Midland Coalfields. However, he did not publish any further information concerning these shells, and thus it appeared that little attention was being given to these forms in Great Britain, and it was even suggested that they were of little value for correlating Coal Measure strata. Meanwhile Profs. Barrois and Pruvost investigated these molluscs in the North of France and other coalfields, and showed in 1919 that they afford most valuable data for zonal purposes. The classic paper published by Mr. J. H. Davies and Prof. A. E. Trueman in 1927 produced a great revival in the study of these lamellibranchs in Great Britain, and it is to the latter that we owe so much of our knowledge concerning the succession of non-marine faunas in the coal-bearing rocks of this country. He has also stimulated many others to become interested in them, with the result that a wealth of information is now available concerning the succession of those faunas in Britain.

In the roof shales of a great number of the coal seams in the British coalfields occur suites of non-marine shells. A detailed examination of these shells reveals marked differences in the species constituting the assemblages found in association with the various seams. The study of these forms and of the assemblages has made it possible for one to identify many coal seams over considerable areas. I could name a great number of seams which can be identified in this way, for example, the Lower Vein, Brasslyd Vein and Pennypieces in the western part of the South Wales Coalfield, where these lamellibranchs have proved of the utmost value to mining engineers in working out the complicated structures of that area. From the mining engineer's point of view, it is unnecessary to learn the scientific names of more than a few of these shells, but the general character of the assemblages can be memorized. It is a question of becoming accustomed to look-out for the typical forms in the assemblages, and this can only be accomplished by systematic collecting from various horizons. As one engineer has often remarked to me 'I don't care what you geologists name these shells, but I know that when I find these little fellows, the presence of the Brasslyd Seam is indicated, and when I find that group of mussels I am near the Lower Vein, and so on'.

Although the non-marine shells are of great value in identifying coal seams, it must be remembered nevertheless that certain shells are no

criterion of an horizon, and an odd shell or two in certain cases cannot be regarded as sufficient evidence for the presence of a particular coal seam. To quote Dr. W. B. Wright, 'The freshwater faunas on the different horizons of the Coal Measures have sufficient distinctness to lend character to the strata in which they occur, and if carefully used, with proper appreciation of their limitations as criteria of horizon, greatly facilitate local correlation'.

(2) *The Value of Non-Marine Shells for zoning the Coal Measures.*—In 1927, Davies and Trueman established a zonal scheme based on the vertical distribution of these lamellibranchs in the South Wales Coalfield. These workers proved that not only could individual seams be identified by means of these shells, but that faunas changed in character, by the appearance of new species and the extinction of others, as one ascended the sequence. As a result of further researches it has been proved that the broad zonal scheme established by Davies and Trueman can be applied in every area where Coal Measures occur in Great Britain. It is also applicable in France, Holland, Belgium, Westphalia and in the Donetz basin. Naturally slight modifications have become necessary as new material has become available, and various sub-zones have been recognized by Dr. W. B. Wright in Lancashire, certain of which have been traced into Scotland by Dr. J. Weir and Mr. D. Leitch. In cases where it may be impossible to identify individual seams in sinkings and boreholes, the recognition of the suites of shells found in the sub-zones may be of great importance to the mining engineer.

The zonal scheme put forward by Davies and Trueman, and later amplified by Trueman and Moore is as follows:—

Stephanian (Westphalian E.). ..	(Zone of Anthracomya prolifera).
Upper Westphalian (C and D). ..	Zone of Anthraconauta tenuis.
	Zone of Anthraconauta phillipsi.
Great Change in Fauna.	
Lower Westphalian (A and B). ..	Zone of Anthracomya pulchra.
	Zone of Carbonicola similis.
	Zone of Anthracomya modiolaris.
	Zone of Carbonicola ovalis.
	Zone of Anthracomya lenisulcata.

Fossil shells are unknown in the uppermost Coal Measures of South Wales, but in the corresponding beds in Radstock, Prof. Trueman and Dr. Moore have described a series of shells including *Anthracomya* aff. *prolifera*, which supports the conclusion based on other evidence that the strata in question should be attributed to the basal beds of the Stephanian (or Westphalian E. of Jongmans and Van der Gracht).

Marine Faunas.

At intervals regional subsidence was sufficient to cause a transgression of the sea over the low-lying swamps. Sometimes the first marine form to appear was *Lingula*. *Lingula* beds and all marine beds generally overlie coal seams of varying thicknesses from ¼ inch up to a foot. *Lingula* beds are often impersistent, and they may pass laterally into shales containing *Carbonicola* and *Anthracomya* or shales with a more typical marine fauna, consisting chiefly of goniatites, nautiloids and lamellibranchs.

Our knowledge of the marine faunas may be attributed to the work carried out by Dr. Wheelton Hind, Mr. J. T. Stobbs, and especially by Mr. W. S. Bisat. Some of the marine beds are widespread, and are fairly frequent in the lowermost Coal Measures, especially in Yorkshire and Lancashire. Two well-known bands occur, namely, the one in the

roof of the Pot Clay Coal (the *Gastrioceras subcrenatum* Marine Bed) and the other in the roof of the Halifax Hard Seam (the *Gastrioceras listeri* Marine Bed), which forms a well-marked datum plane in Yorkshire, Nottinghamshire, Derbyshire and Lancashire, and is also equivalent to the Finefrau Marine Bed on the Continent.

Many other marine beds have been noted in various coalfields in Great Britain in the lower part of the Middle Coal Measures, for example, the Amman Marine Bed in South Wales, which can be traced over a wide area and has been of great economic importance in correlating strata in that portion of the sequence. Some of the other marine beds in the lower part of the Middle Coal Measures are only of limited extent, and although they may be useful in identifying a seam in any particular coalfield or a part of a coalfield, they cannot be used for correlation over considerable areas. Very important marine beds, however, occur near the top of the *Similis- Pulchra* Zone of Davies and Trueman in all the coalfields in Great Britain where the sequence is known, and similar marine beds occur at comparable horizons in France, Belgium, Holland and Westphalia.

Naturally, owing to the scarcity of marine beds in the main portion of the Coal Measures and their complete absence in the uppermost measures, and especially owing to the rarity of cephalopods, marine beds cannot be regarded as ideal fossils for zoning Coal Measure rocks, although they afford the most useful datum planes for wide-scale correlation and can be used for checking conclusions based on other fossils.

Fossil Plants.

Let us next consider the evidence afforded by fossil plants in (1) identifying coal seams, and (2) for zoning Coal Measure strata.

(1) *The Value of Fossil Plants for identifying Coal Seams.*—

(*a*) In the first instance there are the petrifactions found in the coal-balls (calcareous concretions found in certain seams with beautifully preserved masses of vegetable material). These coal balls are restricted to a few seams in the Lower Coal Measures of Lancashire and Yorkshire, but they also occur at a comparable horizon in Holland, Belgium and Westphalia. However, in this case the evidence provided by a study of the petrifications simply supports the identification of the seams based on the presence of the balls in the seam and on the the marine character of the roofs of the seams with their bullions and peculiar marine fossils.

(*b*) It has been found that most coal seams contain certain plant-spores which characterize them and which distinguish them from other seams. While certain spores may be common to several seams, there are usually a few types found only in one seam. Thiessen and his co-workers in America, Lange in Silesia, Dr. Slater, Miss Evans and Miss Eddy and Dr. Wray in Britain have correlated seams based on their spore-content. Their work has been chiefly based on the observations of microspores and more particularly macrospores in thin sections of coal. More recently Dr. Raistrick has carried out laborious and detailed researches on the quantitative analysis of microspores found in the various seams, and in this way he has been able to correlate seams over a considerable area in Northumberland and Durham. In my opinion, caution should be observed in identifying seams purely on the quantitative spore-content, especially seams in widely separated areas. We do not yet know enough about the parent plants of the spores, and the variation in the spore crop may be due to local associations in the coal forests.

(*c*) The evidence afforded by the fossil plants found in the roofs of coal seams (incrustations, impressions) has been used in the identification and correlation of coal seams. Their use has been criticized on the following grounds: (i) their fragmentary character, (ii) they represent

drifted material, (iii) they are rare as fossils at many horizons, (iv) there is no marked change in the species of plants in passing upwards through the Coal Measure rocks. In spite of the fact that plants are fragmentary and that they usually represent drifted material, they represent in fair measure the flora at the end of the forest period and they can tell us a great deal about the flora of the period. Plant impressions are unquestionably rare at some horizons; nevertheless they occur in great abundance at others, and even when they are not plentiful they often throw a great deal of light on the position of the beds in the sequence.

I must admit that I was rather pessimistic about the utility of these fragments until I proved that, with a knowledge of the floras found in their roofs, I could trace certain coal seams over a distance of 20 miles. The most convincing proofs of the value of these impressions has been brought home to me through my good fortune in having opportunities to collect plants in several coalfields in Great Britain and in France, Germany, Belgium and Holland.

When using plants for correlating coal seams, the composition of the whole floral assemblage should be considered and much attention paid to the occurrence of rare species. Several species range through hundreds of feet of strata, and these are frequently amongst the commonest fossils in some assemblages, for example, certain species of *Calamites* and *Stigmaria*. Naturally these plants cannot be used for zonal purposes, yet the presence of a number of fairly long ranged species may occasionally assist one in identifying a seam over a small area, for example, masses of *Sigillariophyllum* in the roof of the Gower Lynch Seam. As in the case of quantitative methods used in the microspore analysis of a seam, so there is a danger in using a purely quantitative analysis of the fragments of plant impressions found in the roofs of coal seams. It is difficult for instance, to say how many *Neuropteris* pinnules should be the equivalent of a *Calamite* stem, and therefore it may be impossible to estimate the percentages of the plants in the assemblages.

(2) *The Value of Plants for Zoning Coal Measure Strata.*—

As a result of detailed studies of the plant impressions we know that the floras of certain periods of Coal Measure times were remarkably similar in widely separated areas from America to the Donetz basin, and that the floras changed in character by the evolution of new forms and the disappearance of others at successive horizons (this has been verified in Great Britain by the work carried out along different lines by Dr. Raistrick and others). The floras become richer and more complex as we proceed upwards through Coal Measure rocks, and they are especially varied in the Middle Coal Measures, where the maximum number of species are recorded. Although the floras were remarkably uniform, yet we know that plant associations existed, governed, may be, by physical conditions or centres for dispersal of new species; there are plants found in North America which are unknown in Britain and *vice versa*, while there are fewer differences between the floras of South Wales and the North of France. Such plants, however, as *Pecopteris aspera* and *Pecopteridium defrancei* occur in particular beds in France, but are unknown in Britain, while *Lonchopteris rugosa* is abundant at certain levels in Holland, Belgium, and in Westphalia, and is common at only one locality in the Bristol Coalfield in Britain.

The utility of fossil floras for subdividing Coal Measure rocks has been recognized for a very long time by workers such as Zeiller, David White, and more recently by Gothan, Renier, Jongmans, Bertrand, Zalessky and Darrah. In this country the great pioneer work on the stratigraphical aspects of palæobotany was carried out by Kidston. Arber also contributed much on this subject. Kidston recognized a succession of different floras in the Coal Measures, and suggested the following classification in 1905:—

Upper Coal Measures	Radstockian Series
Transition Coal Measures	Staffordian Series
Middle Coal Measures	Westphalian Series
Lower Coal Measures	Lanarkian Series.

Later he subdivided his Staffordian and Radstockian Series. Unfortunately Kidston had little knowledge of stratigraphy, and as a result he attributed floras to the wrong portion of the sequence. I believe that he realized many of his mistakes before he died, and that, had he lived a while longer, he himself would have redescribed the succession of floras found in our Coal Measures. In recent years much more information has been obtained concerning the floras of the Coal Measures through the researches of Dr. R. Crookall, Mr. W. D. Ware and others, and they have assisted me from time to time in my work. It has been shown that the Upper Carboniferous of the Swansea area of the South Wales Coalfield can be subdivided into nine floral zones, indicated below. These floral zones can be traced into other areas in Britain, and, moreover, they compare closely with the floral divisions recognized on the Continent and in North America.

FLORA I	Zone of Pecopteris (Asterotheca) lamurensis Acitheca polymorpha Dicksonites pluckeneti Mixoneura (Odontopteris) sp. Alethopteris grandini Sphenophyllum oblongifolium
FLORA H	Zone of Mixoneura (Neuropteris) ovata Neuropteris scheuchzeri Neuropteris flexuosa Odontopteris lindleyana Alethopteris serli Asterotheca arborescens A. miltoni (Pecopteris abbreviata) Sphenopteris neuropteroides Sphenopteris macilenta Diplotmema geniculatum Sphenophyllum emarginatum Annularia stellata
FLORA G	Zone of Neuropteris rarinervis Neuropteris linguæfolia Linopteris munsteri Mariopteris sauveuri Mariopteris latifolia Sphenopteris striata Renaultia chaerophylloides Asolanus camptotænia

Marked Change in Flora

FLORA F	Zone of Neuropteris tenuifolia Neuropteris callosa Asolanus camptotænia Lepidodendron simile

FLORA E	Zone of Lonchopteris rugosa Neuropteris gigantea Sphenophyllum myriophyllum Sphenophyllum majus Annularia microphylla Sphenopteris spp.
FLORA D	Zone of Alethopteris lonchitica Neuropteris heterophylla
FLORA C	Zone of Neuropteris schlehani Lyginopteris hoeninghausi
FLORA B	Zone equivalent to the Pecopteris aspera zone of the North of France
FLORA A	Zone of Lyginopteris stangeri Alethopteris cf. parva.

In using fossil plants to divide the Upper Carboniferous rocks into zones sufficiently thin to be of real value in correlation, attention must be given chiefly to those species with short ranges; frequently these species are rare except at a few horizons, and, since their distribution is incompletely known, the precise boundaries of certain of the zones cannot be definitely fixed. The boundaries of most of these zones must be regarded as rather indefinite, and further research may lead to slight modifications of some of them.

These broad subdivisions based on the distribution of the plant impressions agree very closely with those established by Trueman and other workers on the non-marine shells and by Bisat on the marine faunas.

In concluding one would like to express a word of warning to those who expect too much of the fossils, especially from the point of view of correlating coal seams. The evidence afforded by the fossils is invaluable to the mining engineer and geologist, but it is necessary to recognize their limitations. Odd shells, or individual plants, or forms of no diagnostic value can seldom give the answer to the problem. Some seams can be correlated over wide areas, but there are many which are of limited extent, and owing to the variation in the character of the Coal Measure strata caution should be observed in attempts to correlate too many of our coal seams over considerable areas. Perhaps the scepticism which is expressed by some geologists concerning the utility of these fossils for correlation may be attributed to the economic value of coal and the fact that subsequent mining operations can always prove whether the answer given by the fossils has been correctly interpreted or the contrary. It is possible that such fossils as the graptolites of the Palæozoic or the echinoids of the Cretaceous might risk the reputations attributed to them if boreholes and sinkings in quest of economic wealth were put down at more frequent intervals in the strata in which they are found. Nevertheless, it has to be admitted that palæontological evidence is more reliable than lithological data for correlating the Coal Measures or any other strata; and that what Prof. W. W. Watts has recently termed 'the great principle of the identifications of rocks by fossils, on which are built the widest generalizations of geology' is as triumphantly vindicated by the fauna and flora of the Coal Measures as it is by the fossils of other ages.

14. Dr. Rajnath of Benares and Prof. W. G. Fearnsides of Sheffield also spoke.

15. Prof. B. Sahni, Lucknow.

Concluding Remarks.

More than one contributor has referred to possible discrepancies due to differing rates of evolution in plants and in animals. The rate of evolution is a question of such baffling complexity, with so many interlocking factors which defy analysis, that I hesitated to venture upon a discussion of this aspect.

Does palæontology teach us that in the course of geological time plants as a class have evolved at a different rate from animals? If so, have the one or the other class of organisms consistently evolved at a faster rate, or have plants sometimes evolved faster and sometimes slower than animals? The view has been expressed by Dr. Stanton (p. 172) that 'modern types were introduced somewhat earlier among plants than among animals', and that 'therefore, in America at least, the boundaries between systems and other major geologic divisions when based upon the plant-remains are often placed somewhat lower than the faunal evidence would indicate'. On the other hand, it has been suggested by Professor Cockerell (p. 174) that animals evolve more rapidly than plants. Can either of these statements be made to apply generally, or do they refer only to restricted groups, areas and periods?

Much recent work tends to show that the rate of evolution is not a specific quality predetermined and fixed for each plant or animal but is influenced by the environment in the widest sense. This may be taken to include changes in the soil and climate, as well as those in the biotic factors such as the interdependence of plants and animals, competition within and between species, natural hybridization, etc., etc. This being the case we may conclude that the pace of evolution must have varied in a complex manner even within narrow circles of affinity and in both space and time. Some groups may, while others may not, have altered their previous rates of evolution, and this change may have occurred in restricted areas only. If this was so it is clear that we cannot always speak of a given species (and much less of a given group) of plants or of animals having altered its rate of evolution, because the group or the species may have been distributed over a larger area than that where the environment underwent change.

It is almost a truism to say that evolution must be slower in a relatively static environment, e.g. in the middle of large climatic areas, and faster in dynamic environments such as the sea-coast or along the fringes of climatic zones like the Sahara and the glaciated regions. The recent observations of Hagerup, Tischler, Müntzing and others bear eloquent testimony to this. Apart from the direct effect which has been experimentally proved of the temperature and other factors in producing polyploid and other mutations, there is, along these borderline regions, more conflict and competition, and a wider scope for hybridization.

The greater mobility of animals might at first seem to suggest that they should be less readily adaptable than plants. Because plants move more slowly it might be thought that they must more often perish than animals in an adversely changing environment. But it appears to me that there is a fallacy here. Except in the case of local cataclysms (which cannot be of any significance in this connexion) the rate at which an environment undergoes change is probably never so rapid that, while the animals inhabiting an area can easily migrate, the plants must either perish or eke out a precarious existence with the possibility of getting acclimatized. I think we may take it that in plants, as well as in animals, there is a constant centrifugal urge along the fringes of the areas of dis-

tribution. The seeds of plants are usually already spread beyond the normal distribution areas of the species. Their failure (under static conditions) to extend the distribution of the species is not due to *non-arrival* but to *non-survival* of seed beyond the normal area of distribution. But when the environment (say, the climate) undergoes change these seeds would be able to germinate and the border lines of distribution would be adjusted accordingly.

Thus we may conclude that the rate of horizontal spread of species is always faster than the rate of movement of any large environmental change. Hence it would seem that for purposes of effective migration plants, although less mobile in the ordinary sense, are probably not slower than animals.

From what I have said it seems that we cannot speak in general terms about plants and animals as a whole evolving at different rates. Nevertheless the local preservation of residual forms may tend to cause slight discrepancies. Such forms therefore deserve special attention.

Referring to Mr. Crookshank's remarks, I am glad he also thinks that Dr. Spath is not justified in extending to the Rajmahal flora in Behar the conclusions he has drawn from an examination of the Madras Coast ammonites. I may, however, be forgiven if I find it difficult to endorse Mr. Crookshank's palæobotanical reasons for this view. My difficulty is (as I said in my opening remarks) that we do not yet know enough of the Jabbalpur and Umia floras to be able to make any helpful comparisons with the Rajmahal flora, which is now fairly well known.

The modern tendency in palæobotany is not greatly to reduce the number of species based upon leaf impressions, as Mr. Crookshank believes, but, I fear, it is just the reverse: with intensive work on the cuticles and fertile parts of these leaf 'impressions' the number of species is steadily mounting up. The specific instance of *Ptilophyllum acutifolium* chosen by him is particularly unfortunate because it is just here that recent work has helped to split up that 'species'. The name *P. acutifolium* was formerly applied in a comprehensive sense to a number of different types of cycadean fronds which were grouped together merely on grounds of convenience.

XXXI. THE ABSORPTION OF SALTS BY PLANTS.

(*Sections of Botany and Chemistry, in co-operation with the Society of Biological Chemists, India.*)

Profe. V. H. Blackman, London, presided, and Prof. P. Parija, Cuttack, opened the discussion.

1. Prof. P. Parija. Cuttack.

Opening Remarks.

The problem of absorption of salts by plants is of such great theoretical and economic importance that no justification is necessary for the choice of this subject for a joint discussion. On behalf of the President of the Botany Section I have the honour to invite the distinguished scientists present here to discuss this very important problem in all its aspects so that scientific workers in pure and applied plant physiology all over the country may get light and guidance in their further search for knowledge.

As a humble student of plant life, I can only put before you some points which may serve as the nuclei for discussion.

Salts, or should we say ions, are absorbed by root hairs, rhizoids or other absorbing organs. Any factors which will affect the growth of these absorbing structures will affect the absorption. Thus, for example, 0·3%

NaCl will produce an average root hair length of 30 as compared to 6 in KNO_3 of the same concentration while Boric acid (0·02%) will produce 45 in *mustard*. Other external factors will also influence absorption.

Apart from these, the living cells do manage to take in and sometimes accumulate ions inside them (case of *Valonia* by various authors) in excess of the outside concentration.

There are various aspects of this problem. I want to invite your attention to only a few points which I think deserve more consideration than they have received.

In absorption of salts, the surface cells of the absorbing organs, be they roots, haustoria or submerged organs of water plants, are all important. It is taken for granted that the walls of these cells do not play any other part except exerting what is known as the wall-pressure when the cells are turgid. That is to say, the cell-wall only plays a passive rôle.

Now the question is whether the cell-wall is really passive. The cell-wall is after all a colloidal sheath and as such its physical condition is subject to modification according to the constituents of the solution that bathes it. What part do these modifications play in the process of absorption?

The Cell-Wall—not homogeneous. In cross section various striations are visible, sometimes quite easily. Kerr and Bailey point out that even the middle lamella consists of three layers. Stratification, according to the micellar theory, is the result of the arrangement of micellæ.

The most widely held idea is that the micellæ are crystalline (Frey, Wyssling, Meyer, Herzog and Clark) and these submicroscopic micellæ are packed, so to speak, in a hydrophylic colloid.

Thus apart from the lamellation which one sees in the cell-walls of algæ, there is heterogeneity even in each lamella and the intermicellar spaces are liable to alteration and thereby increase or decrease the permeability of the cell-wall (Gurewilsch).

If this is true of cell-walls of absorbing organs then do these various interfaces have any influence on the absorption of salts?

Is the cell-wall really passive? Some workers like Lloyd have doubted this especially in the case of algæ.

They even go so far (Lloyd and Ulehla in *Postelsia* Crammer) as to regard the cell-wall as a living structure subject to irreversible changes like death. More attention must be paid to the cell-wall than has hitherto been done.

There is another point with regard to the cell-walls which deserves attention. We are apt to leave out of consideration the gelatinous sheath of the walls of many absorbing cells (e.g. blue-green and green algæ).

Again in the lamellated cell-walls, such as one finds in some algæ, the interfaces between the lamellæ may not be without influence on the absorption.

(1) One is confirmed in one's doubt as to the passivity of the cell-wall, when one remembers how intimately the cell-wall and the plasma membranes are connected and the influence which different salts and their concentrations have on the development of the root hairs.

(2) We have next to turn our attention to the all important plasma membrane. The plasma membrane is admittedly a colloidal mosaic of proteins and lipoids. The unidirectional growth of root hairs indicates that the plasma membrane is not of uniform composition all-round the piliferous cell.

Plasma membrane.—Passing from the cell-wall, one comes to the all-important plasma membrane. This membrane is admittedly a colloidal mosaic of protein and lipoids, which is not of uniform composition all-round the absorbing cell, as shown by the unidirectional growth of root hairs.

This membrane is closely adpressed to the cell-wall. As we have seen before, the cell-wall is traversed by transverse submicroscopic passages of hydrophilic colloids. Whether these colloidal passages are ramifications of the plasma membrane as some people think?

If this is so, then the real region of study shifts from the plasma membrane to the surface of the cell-wall. That there is intimate connection between cytoplasm and the cell-wall is shown sometimes at sudden plasmolysis where strands of cytoplasm are torn out.

If these hydrophilic colloids are not continuous, then what part do they play in the passage of salts?

Energy must be expended to maintain the colloidal complex constituting the plasma membrane in efficient condition. The fact that the root hairs in higher plants grow, live and die means that this necessary energy supply somehow fails or possibly the very salts which are absorbed in the process of absorption bring about an irreversible change in the colloidal complex, thus bringing about death.

(3) The next point to be remembered in a multicellular organism is the correlation between the surface cells and those in the interior.

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2. Mr. B. Sen, Calcutta.

Living protoplasm and the plasma membrane.

The quantity of salts absorbed by plants can be followed accurately by measuring under controlled conditions the diminution of solute concentration of the culture medium. But when we consider the *mechanism* involved in this process of absorption, we have to struggle more with theories than well-established conclusions.

The epidermal cells of the absorbing tissue are the primary units through which absorption of salts takes place in plants. The cell-wall is now generally accepted as freely permeable to both water and solutes; it is the plasma membrane of the cell which functions as the selective barrier for all entering ions. Therefore the plasma membrane is the most important determining factor involved in the process of salt absorption by plants.

The most recent general discussion on the subject of the 'Properties and Functions of Membranes, Natural and Artificial' (*Trans. Faraday Soc.*, 1937, **33**, pp. 911–1148) has reminded us, however, that (i) most of the problems concerned with the structure and functions of the plasma membrane still remain unsolved, despite several very suggestive theories advanced and many admirable models devised; and (ii) more definite information about the nature of living protoplasm itself is badly needed, before further speculations can become really fruitful. Conclusive experimental data about the most elementary physical properties of protoplasm are surprisingly meagre and often contradictory. It is now generally accepted that protoplasm is a colloidal complex, but agreement is lacking as to whether it is a suspensoid or an emulsoid. Similar disagreement is to be found regarding its viscosity, that is, whether protoplasm is a sol or a gel. The very existence of the plasma membrane as a distinct morphological entity is still being questioned by some.

Elsewhere (Sen, B. 1934, *Ann. Bot.*, **48**, 143–51; 1937, *Ind. Jour. Agri. Sci.*, 7, 479–485) the writer has enumerated the difficulties inherent

in experimental observations on living protoplasm, as also the special facilities which root hairs of *Azolla pinnata* afford for ultramicroscopic observations on living protoplasm. An *Azolla* root hair is practically a cellulose capillary filled with transparent protoplasm. For the present discussion, the results of my observations on living protoplasm and the plasma membrane may be summarized as follows :

(1) The ultramicroscopic picture of living protoplasm of *Azolla* root hairs shows bright particles in vigorous Brownian movements.

(2) The colloidal particles of living protoplasm of petiole hair of the stinging nettle (*Urtica dioica*), root hairs of *Azolla*, tubes of germinated pollens (unpublished data) of Sweet Peas (*Lathyrus odoratus*), *Petunia*, and Madonna Lily (*Lilium candidum*) are *negatively charged*, as found from their cataphoretic migration. This charge remains negative as long as the protoplasm maintains its living structure.

(3) Bivalent cations, in isotonic concentrations, when injected by micro-pipettes or introduced inside the protoplasm by the Increased Permeability technique, induce irreversible flocculation. Ca and Sr exhibit specific reactions not shared by Ba and Mg.

(4) The viscosity (unpublished data) of *Azolla* root hair protoplasm, as determined by camera lucida tracings, on a uniformly moving horizontal plate, of Brownian movements of single particles, is found to be of the order 3 to 4 times that of water.

(5) The dispersion medium of the living protoplasm of the different cells investigated, appears to be an aqueous solution, and the immiscibility of protoplasm and water is due to the presence of a membrane. When this membrane is destroyed, the protoplasmic mass diffuses freely in water and aqueous solutions (unpublished data).

(6) The morphological existence of a plasma membrane, differing in chemical composition from the bulk of the protoplasm, has been demonstrated (unpublished data).

(7) The normal plasma membrane of *Azolla* root hair and also membranes formed round beads of protoplasm of plasmolyzed hairs show similar reactions to different cations, and the permeability of both increases when they are effectively stimulated by an induction shock (unpublished data).

These data indicate that, at least within the visible limits of the ultramicroscope, the protoplasm of the cells studied exhibits more of the properties of a suspensoid than of an emulsoid.

3. Dr. S. Ranjan, Allahabad.

The subject of salt intake by plants is a very vast one, presenting many aspects for consideration. The entrance of salts is influenced by various internal and external factors. There is also evidence to believe that the absorption of salts is not only intimately connected with the nature and composition of salts but also with those of the living protoplasm.

Thus the problem of salt intake is more to be looked at from the physiological point of view than from the purely physical. The older theory that inorganic salts enter plant cells in the dissociated or ionic state only is quite untenable in view of the works of Irwin, Osterhout and others which indicate that in certain cases at least compounds in the undissociated form have the power of entering the cells. It is generally thought that the entry of salts is made possible because of concentration gradients—salts diffusing from the medium of higher concentration to one of lower in respect of these salts. It is contended that the concentration of soil solution in respect of these salts is higher than that of the cell sap. But such a condition cannot exist indefinitely unless the salts entering are translocated away or are somehow rendered osmotically inactive; otherwise sooner or later a state of balance will be attained. Moreover it has been definitely proved that *Chara* and

Nitella cells have the power of accumulating certain salts in concentrations higher than those in the external solution.

Breazeale postulates that it is the colloidal particles of the protoplasm with a definite electrical charge that are instrumental in effecting entrance of salts. The charge is transferred from its place of origin to the epidermal cells of the roots where it must be satisfied; therefore the oppositely charged particles must be absorbed. It must be noted here that colloids are heterogeneous systems of unstable equilibrium, the particles being dispersed in the suspending liquid because they carry the same electric charge. The effect of ions on the colloids is to disturb their electrostatic equilibrium. It is, therefore, not difficult to imagine a complex system of anions and cations within the plant cells which operate in such a way as to effect the entrance of salts or rather dissociated salts.

It is also quite conceivable that protoplasmic rotation may have something to do with the intake of ions. Lapique considers that by rotation each portion of the protoplasm of the cell is alternately brought in contact with the external solution and the vacuolar sap. It is well known that proteins, one of the constituents of the protoplasm, are amphoteric compounds and on the acid side of the iso-electric point combine with anions and on the alkaline side with cations. It therefore seems that the absorption of ions is a function of the protoplasm itself through its constituent proteins. The work of Pearsall and Ewing lends weight to such a conception of ionic intake. The intake of salts or ions is therefore a direct metabolic phase of the living cell—accumulation being effected at the expense of metabolically derived energy. The conception of cell-colloids as having to do with the absorption of ions might possibly be correlated with the absorption of nitrate and ammonium nitrogen. It has been contended that these two forms of nitrogen are absorbed at different hydrogen ion concentrations of the medium. This suggests that the cell-colloids are oppositely charged at the time of the intake of these two forms of nitrogen respectively. Thus there is evidence to believe that nitrate nitrogen is absorbed at a relatively high concentration of hydrogen ions—probably in the neighbourhood of pH5, while ammonium nitrogen is taken in at a lesser acid or even alkaline reactions.

4. Prof. V. H. Blackman, London.

The view I wish to stress is that the absorption and accumulation of salts by plants is a dynamic process, not a question of equilibria. Work must be done to attain a higher concentration inside the cell than without it. We know that certain plant cells such as hairs can secrete almost pure water from a concentrated cell sap. Similarly the kidney secretes weak salt solution, the urine, from a strong salt solution, the blood. Work must be done in these cases and the energy for that can come only from metabolic processes.

The absorption of salts by plants cannot be explained by passive models of membranes with certain permeability characteristics. Such models simplify the problem so that it has little relation to reality.

The work of Steward with potato slices has shown that absorption is closely related to aeration and to the rate of CO_2 output, i.e. to rate of respiration. This clearly demonstrates the relationship of accumulation of salts to the rate of metabolism.

Tissues such as bulb scales and the flesh of the apple fruit have no power of growing and dividing and fail to accumulate Br. from Pb. Br. even under favourable conditions of temperature and aeration. Such tissues produce CO_2 but do not accumulate salts yet in the Osterhout model the exit of CO_2 is an essential part of the mechanism of accumulation of potassium. Again, *Nitella* and *Elodea* in the light actively accumulate the bromide ion yet CO_2 is not passing out but entering the cell.

Uptake of salts must be studied in *relation to the whole cell*, not merely in relation to the cell wall or to the protoplasmic living layer. The problem is not yet in a state of development suitable for chemical or physicochemical analyses.

5. Dr. B. N. Singh, Benares.

The phrase 'absorption of salts by plants' may easily imply a range of investigational activities entirely too broad to be discussed in a single discourse specially one so strictly limited as to its length. In a study of the mineral nutrition of a plant there are many factors which must be considered for the intake of nutritive elements involves complex chemical and physical processes. It has become evident during recent years that the absorption and accumulation of elements by the plant cell in the course of their normal nutrition involve processes which may easily escape proper study in so far as most investigations on permeability of cell membranes are concerned. The investigator of the permeability of plant cells is often constrained to employ highly artificial environmental conditions (high concentration of solutes, use of solutes foreign to the cell, unsuitable conditions of light or aeration, etc.), or to work over very short periods of time. Investigations of such nature have their own limitations and hardly serve to elucidate the gradual intake of electrolytes by the growing or actively metabolizing plant.

Much work has been carried on covering several years on the intake of certain more important elements and it is now definitely indicated that of all elements potassium has been universally found at concentration in the cell sap much higher than that in the external solution. The evidences collected during the past ten years on the absorption of this element by apparently closely related and similar species and varieties of crop plants chiefly of the Gramineæ order, when grown in culture media of similar mineral constitution, indicate how widely the rate of absorption differs with the variety as well, and in certain cases with the individuals of the same variety. Evidently highly generalized statements with regard to the physical chemical properties of the different chemical elements in relation to their intake by plant cell must be made with caution.

Among the factors that vitally determine the absorption of salts from liquid media, the aeration of the solution has been shown to be most important. While conducting a series of very carefully controlled studies on the absorption and accumulation of certain elements, it has been definitely shown that the respiratory activities of the root cells are indispensably involved in the process of accumulation. Significant differences in the rate of absorption in different varieties of the same plant did not occur except when the medium was suitably aerated. Under conditions of proper aeration favouring optimum respiration of the delicate rootlets and root hairs striking differences were obtained. In all these experiments aeration of solution did not merely carry away the CO_2 evolved by the roots but also supplied oxygen for proper respiration. Maximum accumulation of electrolytes was attained under those conditions which provoked maximum aerobic respiration of the root. Excised roots of these very plants too show but little or no power to accumulate electrolytes under non-aerated conditions whereas under proper aeration seedlings accumulate these ions very rapidly. In all such cases it has also been marked that the metabolic state of the roots as determined by culture conditions existing previous to excision is also of great importance.

It has further been demonstrated that while the absolute amount of solute absorbed by the plant increases with increasing concentration of the solute in the external solution, the amount absorbed relative to the external concentration nevertheless decreased rapidly from the lowest concentration upwards. When the external concentration of the solute is low the absorption rates become more than unity, while under high external concentrations, the absorption rate is always less than unity.

The degree of absorption depends not only on the concentration of the external solution but also upon the nature of ions absorbed. Thus the absorption of nitrates cannot be considered independently of the absorption of cations inasmuch as their effect on such plant characteristics as protein content of wheat are concerned. The quality in protein is known to vary with the character of the culture media, the nature of nitrogenous salt supplied and particularly the concentration of the nitrate ions in the medium as expressed by the results of extreme conditions of no nitrate on the one hand and ample quantities of nitrogen salts on the other.

The reaction of the solution is another important factor in the absorption of salts. Investigations in this regard have shown that for each species and variety of the crop plants there is a specific range of *p*H at which optimum absorption takes place. Toxicity is more likely to occur if in spite of other favourable conditions the acidity of the sap is not maintained within certain range of the optimum for the species.

Light has particularly been shown to influence the intake of K and N ions. With increase in either the intensity or the duration of artificial illumination, it has been found that wheat plants grown in water culture accumulate more of these ions. Above a certain range of intensity and duration the reverse effect is clearly noted. This indicates how a purely external factor has influence on the absorption of the simple inorganic entities.

Temperature of the medium too introduces significant differences in so far as the total quantity of solutes absorbed by the plant is concerned. Thus in three series of cultures of wheat grown at 45, 35 and 30°C., respectively it has been shown that the total ash content after a period of 45 days increases with the increase in the temperature of the culture from 30 to 35°C., and later exhibits a marked decline. This optimum temperature was found useful for all studies on absorption.

Humidity of the atmosphere has also been found to greatly regulate the intake of solutes from the soil but it cannot be said with certainty whether it has any direct effect on the intake of solutes. When grown in an environment with humidity above 75% wheat plants failed to absorb as much of nitrogen from the medium as under relatively drier atmospheres (50% humidity). Such variations in the absorption rate are correlated with the transpiration values under the two conditions but it cannot be vouchsafed for the present that the evaporation of water from the plant has any direct bearing on the rate of absorption of ions.

Of special interest in this connection is the relation between the intake of solutes and the metabolic needs of a growing plant. The data collected in this connection indicate that in a majority of cereals and few other plants, the absorption of soil constituents is characterized by three distinct phases, co-extensive with the more important stages of vegetative development. The first of these covers a period of progressively increasing rate of absorption ending about the time the heads begin to form. At this time it is frequently observed that the absolute amount of potassium and nitrogen contained in the plant approach the magnitude present at complete maturity. The beginning of the second phase is indicated not merely by a decreased rate of absorption but by definite and substantial losses of certain constituents notably potassium, nitrogen and calcium from the portions of the plant growing above the ground and presumably from the entire plant. The loss is more or less concurrent with the migration of the same constituent into developing heads. The end of the second phase is characterized by a tendency to absorb again the soil constituent previously lost. This may result in taking up considerable quantities of these elements when the plants are large and well developed. The third phase occurring at the time of the ripening of the grain is marked by a practically complete cessation of absorption of all constituents and an actual loss of most of them.

While such cyclic variations in the absorption rates of certain elements characterize different species and varieties of plants experimented upon, it may incidentally be remarked that specially in soil and sand fertilizer cultures, the losses of potassium and nitrogen at certain stages of the life cycle occur when the constituent of the water extract of the soil were at or approaching their minima and when the same constituents were moving from leaves to the heads. Much, however, depends upon the specificity of the plant material, the specific needs of the plant at various stages of growth and development, and the relation which the process of absorption might have with other metabolic activities of the plant.

Attention may specially be recalled at this stage to the characteristic relation between the age-factor and rate and order of absorption of ions on the one hand, and the relation between the intake of certain elements specially potassium and calcium and the photosynthetic efficiency of plants on the other. While the ions in case of one single species are not absorbed at the same rate and in the same order at successive stages, there does seem to exist some correlation between the quality of these absorbed and the specific metabolic rate. Thus a higher rate of absorption of potassium and calcium has always been shown to be associated with a higher rate of photosynthesis and *vice versa*.

The phenomenon of the relative intake of nutrient elements from culture solutions is further complicated by the antagonism between different ingredients, the unequal absorption of component ions and the selective absorption of these ions by the species under consideration. In considering this aspect, however, we cannot but take into consideration the quality and state of protoplasm more particularly the amphoteric nature of plant proteins, the biochemic constitution of the species, and the nature of the particular stimuli—physical, chemical or mechanical, the effect of which is being investigated.

The whole question as a matter of fact remains yet to be carefully analyzed and unless large amount comparative data under different conditions and stimulii specially from water culture experiments, sand water culture, soil pot cultures, field experiments and so on, and under as many different combinations of factors as practicable are available, it is rather difficult to arrive at any definite generalization. Strictly controlled experiments with a parallel study of the different plant processes directly bearing upon the question of absorption of salts might also aid in solving the still little understood processes connected with the intake of ions by plants. It is also desirable to call attention to the extensive investigations of Mason and Maskell. They suggested that re-export towards the roots of certain elements *via* the phloem may have a bearing on the rate of absorption of such elements by the root cells. The relation or lack of relation between transpiration and absorption of mineral elements is also thought to be involved. The absorption of these elements may thus involve problems of plant anatomy as well.

Summarizing the whole question it may be remarked that the mechanism of living cells involved in the absorption of salts, which is undoubtedly of exceedingly great intricacy, has not yet been disclosed through any direct experimental approach although we have before us many of the suggestive explanations of the phenomenon put forward by various workers from time to time. Among the theories advanced during the past few years mention may be made of the ionic exchange theory of Brooks and Briggs, Osterhout's conception of undissociated molecules entering the root cells, Breazeales's theory of physical absorption, the epictesis theory of Lapique, etc. The conception of a simple Donnan equilibrium too is inadequate to explain the phenomenon of ionic intake since the interior of plant tissues is known to comprise a number of phases each of which may be in Donnan equilibrium with the external solution and under which circumstance product of the apparent internal ionic concentrations resulting from the total effect of all these phases is shown to be greater than the external product. Not entering into the relative

importance of these results and others each of which have their own limitations, it may be of use to remark that studies on the absorption of salts by plants grown on natural soils, particularly those yielding good crop, have important applications in investigation for determining the conditions for optimum growth by means of sand and water cultures; for while the amount of a given constituent absorbed does not necessarily indicate the quantity essential to proper development, fluctuations in the rate of absorption may be expected to reflect, at least to a certain extent, the nutritional peculiarities of the crop and serve as a guide in regulating the concentrations and amount of solutes at successive stages of growth.

6. Dr. V. Subrahmanyan, Bangalore.

Influence of the soil on the absorption of salts by plants.

I wish to confine my remarks to just one aspect of the subject which is important from the agricultural point of view, viz., the influence of soil on the availability of salts for plant nutrition.

A very large part of the literature on the subject of salt absorption relates to water-culture studies, but the results thus obtained, though fundamentally very important, are hardly applicable to field practice.

As an example of the above, one may cite the commoner experience with phosphates. Alkali phosphates, which are completely available in water cultures, are only very poorly so in the soil. This is due to the ready solubility of these salts in water and consequent interaction of the anion with the soil complex. The result is that the phosphate is rendered more or less unavailable in most types of soils. On the other hand, alkaline earth phosphates which are insoluble in water are very much more available than the alkali salts and continue to remain so for long periods. Thus, calcium phosphate does not react with the soil complex, but nevertheless is readily available to the plants. In a recent enquiry conducted at Bangalore, Srinivasan and Sadasivan have adduced evidence to show that calcium phosphate is solubilized by the plant in just the requisite quantities, so that very little surplus soluble phosphate is left over for interaction with the soil. Indeed, an elegant way of retaining the availability of soil phosphates is to convert them into calcium salts through basal dressings of caustic or carbonate lime. Another and an equally efficacious method of increasing the availability of phosphates in the soil is to apply soluble silicates. Srinivasan has recently shown that colloidal silica which is the first product combines *preferentially* with the mineral complex of the soil, thus releasing phosphate for plant nutrition.

Another direction in which the soil plays a very striking part is through interaction with metallic ions. A number of previous workers have shown that manganese salts, in even very minute quantities, have profound effect on water-cultured plants. This effect is essentially ionic and is directly traceable to the influence of the manganese ion. Beneficial effects are also observed in the soil, but then the manganese salts behave in an entirely different way. When applied in moderate quantities (say, 1-2 cwts. per acre), a soluble manganous salt is rendered insoluble almost immediately after addition to soil. The subsequent changes are of very considerable scientific as well as practical interest. Harihara Iyer and Rajagopalan working at Bangalore have shown that under normal conditions, the manganous salts are turned into manganese dioxide, which has a highly beneficial effect on crops. Oxidation of organic matter is hastened, thus releasing more food for plant nutrition. Biological activity is also stimulated. Increased yields ranging from 25–100 per cent. (depending on nature of crop) have actually been obtained. Even highly oxygenated compounds like permanganate first get reduced to manganese dioxide and then exercise a beneficial effect on plants. It would thus be seen that application of soluble manganese salts is an elegant

method of supplying the insoluble but nevertheless potent manganese dioxide to the soil.

The above observations do not entirely preclude ionic effects. It may, nevertheless, be pointed out that, in the case of tomato grown on soils with and without manganese salts, there was no significant difference in regard to their manganese contents. On the other hand, ragi grains (*Eleusine Coracana*) from manganese treated plots had a slightly darker colour than those from the control plots. We have yet no evidence to show how this effect is produced.

Soluble iron salts behave in a manner similar to the manganese salts. They get mostly converted into finely divided ferric oxide and thus facilitate oxidation changes in the soil. When applied in moderate quantities they also lead to increased crop production.

One rather interesting observation which has recently been made by Asana at Bangalore is that soluble ferrous salts are more beneficial than the corresponding ferric salts to water-cultured rice plants. The mechanism of the phenomenon is still not clear. It may be interesting to mention in this connection that in the manured swamp soil there is always some soluble ferrous iron in the early stages. This may be one of the beneficial effects of swamping which is so favourable to the rice plant. As already mentioned, the ferrous salts which result from the initial fermentation are subsequently converted into finely divided ferric oxide and thus exercise further beneficial effect on the plant.

7. Prof. A. H. R. Buller, Manitoba pointed out that so far as his experience went, the cell-wall did play a part in the absorption of salts by the plant cell.

8. Prof. V. H. Blackman, London, wound up the discussion laying stress on the all-important function of the protoplasm. As evidence he cited the fact that absorption was affected by the absence of oxygen.

XXXII. THE SPECIES CONCEPT IN THE LIGHT OF CYTOLOGY AND GENETICS.

(Sections of Botany, Zoology and Agriculture.)

Prof. B. Sahni and later Prof. S. R. Bose presided, and Dr. (Miss) E. K. Janaki Ammal opened the discussion.

1. Dr. (Miss) E. K. Janaki Ammal, Coimbatore.

Opening Remarks.

It has been said that the test of the creed of a biologist is his definition of species. Though modern genetics has thrown considerable light on the nature of genetical differences between related species, at no time has it been more difficult to define species as at the present day. This is mainly because we now know more of the underlying causes of variation or discontinuity that exist between two forms than we did 20 years ago. These causes are now found to be different in the case of different species and genera.

The cyto-genetic analyses of plants and animals have shown that though the differences between some species are mainly gene differences, in others they are associated with changes in (1) the number, and (2) the structure of chromosomes. The discovery of plants with chromosome

numbers which are multiples of a basic number is so widespread that it has been observed in nearly every genus that has been examined critically. This discovery gives polyploidy a practical importance in tracing the phylogeny of species.

'Secondary pairing' of chromosomes at meiosis was first used by Darlington to interpret the history of the Pomoideæ.

By the synthesis of *Galeopsis tetrahit* from *G. pubescens* and *G. speciosa*, Müntzing was the first to show that Linnean species had arisen by hybridization and doubling of chromosomes. It is now known that many genera and species of cultivated plants are allo-polyploids. A number of artificially produced forms like *Primula kewensis*, *Nicotiana digluta* and *Digitalis mertonensis* have been produced by the same way, while 'amphidiploid' intergeneric hybrids like *Aegilotriticum* and *Raphano brassica* have been raised to the status of new genera.

The ease with which it is possible to hybridize widely differing genera in the family Gramineæ when factors that contributed to their isolation are removed, is shown by the many hybrids produced at Coimbatore between species of *Saccharum* and those of *Sorghum*, *Erianthus*, *Narenga*, *Bambusa* and *Imperata*.

'The indigenous canes of India, the so-called *S. barberi* and *S. sinense* of Jesweit occupy taxonomically a position intermediate between the noble cane *S. officinarum* and the wild species *S. spontaneum*. These latter represent a polyploid series ranging from $2n = 48$ to $2n = 80$ in India and $2n = 80$ to $2n = 124$ in Further India and E. Indies. In *S. barberi* and *S. sinense* aneuploid number ranging from $2n = 82$ to $2n = 124$ have been observed.

Evidence for the origin of *S. barberi* from *S. spontaneum* has been obtained from the study of occasional giant triploids with $2n = 84$ (triplopolyploids) which arose amongst selfed progenies of a *S. spontaneum* ($2n = 56$) in Coimbatore. These were found to be thicker and have more sugar than the type from which they arose and the resemblance to *S. barberi* was very pronounced. The occurrence of such giant triplopolyploids amongst intraspecific hybrids between the different chromosomal forms of *S. spontaneum* and the phenomenon of heterosis met with in crosses between widely separated forms of *S. spontaneum* seem to point out that hybridization must have played an important part in the evolution of the cultivated cane.'

2. PROF. R. RUGGLES GATES, London.

On the gene theory variations arise, at any rate for the most part, in the chromosomes, and express themselves in ontogenetic development. An understanding of species and other categories of taxonomic classification must then ultimately be based upon an analysis of how chromosomes change. The conceptions associated with the terms linneons, jordanons, and syngameons have proved most useful in the genetic analysis of species and their variations.

From the cytological point of view we may classify chromosome changes as changes (1) in number, (2) in structure. Changes in number include: (*a*) polyploidy, so characteristic of plants, (*b*) polysomy, (*c*) fragmentation, (*d*) fusion of chromosomes. Structural changes include (*a*) segmental interchange, (*b*) duplication, (*c*) reversal, and (*d*) deletion of a portion of a chromosome. Some of these changes involve no immediate phenotypic change in the organism, but they serve as a basis on which future differentiation of type can take place.

Comparative cytology throws light on the processes by which these changes in number have taken place. The study of chromosome structure combined with comparative genetics shows how rearrangements within the chromosomes have been taking place. Examples are the location of parallel mutations in the chromosomes of *Drosophila melanogaster*, *D. pseudo-obscura*, *D. virilis* and other species; or the catenation of chromo-

somes in different *Oenothera* species. This appears to have come about through segmental interchange accompanied by genic mutations and followed by intercrossing. In all cases the ultimate raw material of evolution appears to be supplied mainly by genic mutations. The study of mutation rates and their natural methods of change may ultimately throw some further light on the origin of this 'raw material'. Different genera of plants and animals have specialized in different methods by which the genes thus produced are rearranged, multiplied or interlinked.

Many interspecific crosses both in plants and animals show that their differentiation has arisen through genic mutation. Examples, *Antirrhinum, Peromyscus*. In certain genera, e.g. *Oenothera*, there is evidence of cytoplasmic differentiation as well. Other types of cytological change come in to complicate the results by linking the genes in fresh groupings.

It was supposed until recently that interspecific sterility could only arise over a long period and had never occurred in experiment. Some biologists still regard it as an essential criterion of species. Intersterility is, however, no longer a sure guide even regarding nearness of relationship between types. We can now see in many cases how it has either arisen in experiment or must have arisen in the recent past. The numerous cases of amphidiploidy in plants and change in chromosome number or segmental reversal in various genera furnish such evidence. The natural selection of parallel mutations in species which have become intersterile, means evolutionary advance on a common front.

The genus *Oenothera* has evolved simultaneously chromosome catenation and small self-pollinating flowers. Under these conditions the seeds from each individual produce a pure line. Catenation preserves the advantages of heterosis. Occasional crosses occur, producing new types which again breed true. Thus the whole Onagra section of *Oenothera*, containing over 75 species, is a syngameon containing numerous linneons which occasionally intercross when dispersal brings them into contact. This, combined with gene mutations, produces a network of cross-related forms, linneons, jordanons and many smaller differences.

3. Dr. C. D. Darlington, London.

The Integration of species.

We are generally agreed that species arise, as Darwin said, by the selection of hereditary variations. We are not agreed as to how the selection takes place. It must depend on the nature of the variations that are available for selection. These are broadly of three kinds : changes in the internal properties, linear positions and quantitative proportions of the genes making up the chromosomes. These three must be selected so as to provide the means of isolation and adaptation. The comparison of species and the study of their hybrids show that the chromosomes are continually undergoing structural rearrangements which in various ways prevent crossing-over between the genes in the rearranged parts. These structural changes provide the means for holding together groups of genes and thus allowing for the preservation of good combinations. This is the first step in the integration of species. Structural changes also cause changes in the proportion or balance of the genes in the complement, thus adapting them to different environments. This is the second step in integration. Finally structural changes inhibit the pairing of the relatively changed chromosomes and lead to intersterility. This is the third step in integration. Where polyploidy is the agent of species formation the mechanism is different, but the three essential steps remain the same.

4. Dr. E. W. Erlanson, Budge Budge.

Genetics has helped to explain (*a*) variation within the species, and (*b*) parallelism in related species. The application of this improved

understanding resulted in the reduction of the number of American species of *Rosa* from 115 to 20. Cytology has thrown light on phylogeny and has solved some problems of phytogeography. We have finally broken away from the concept of a morphologically delimited species with a definite range and have adopted a three-dimensional fundamental unit the 'line of evolution' in both space and time for each species. It has been shown that interspecific relationship is a complex reticulum rather than dendritic. The unique cytological behaviour of the common *Caninæ* roses has distorted the perspective of some European workers who have persisted in the fallacy that modern diploid roses are descended from polyploid ancestors. This hypothesis is not necessary to explain the cytological conditions. The fact that the higher balanced polyploid rose species are both the most primitive morphologically and the most boreal in range has also been used to support the theory. The physiological effect of polyploidy is to increase cell size, slow down growth rate and increase adaptability. In *Rosa* the higher polyploids are physiologically best adapted for near arctic conditions. Their very polyploidy is a bar to further evolutionary progress, although as allopolyploids they may act as sources of new genes which appear in diploid descendants of hybrids between them and diploids. There are both generalized and specialized tetraploid rose types and tetraploids have arisen more than once on the American continent. The diploid *R. Woodsii* (near relative of the Eurasian *R. cinnamomea*) has the greatest north-south range of any rose. It is generalized and primitive morphologically and there is no reason to suppose that there have not always been diploid lines of descent in the genus which have given rise from time to time to the polyploids with which they still hybridize freely.

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